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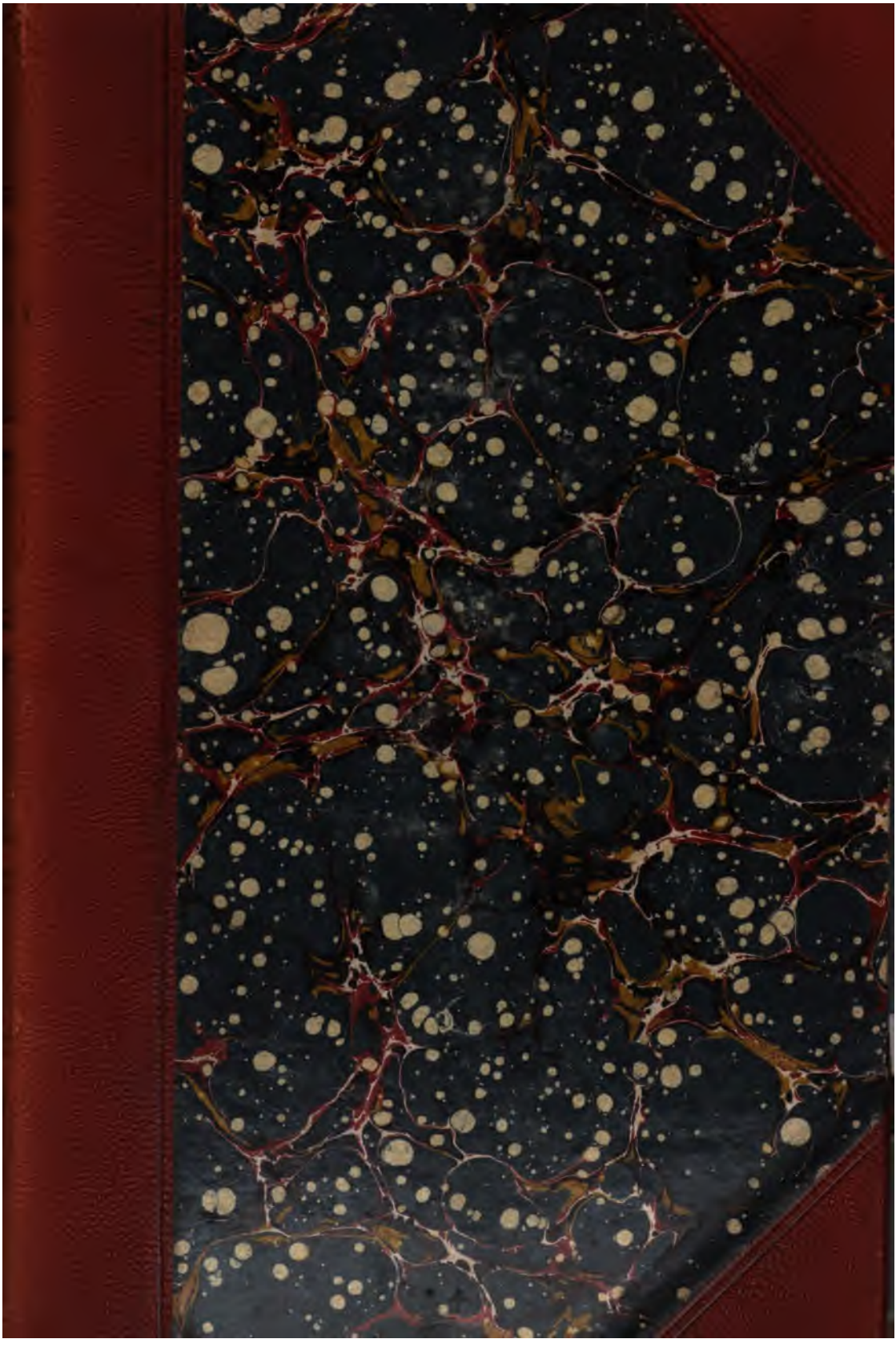

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TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME NINETEENTH.

PARTS I.—XX. 1886-87-88.

MANCHESTER:

SOLD AT THE ROOMS OF THE SOCIETY,

36, GEORGE STREET, MANCHESTER.

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*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XIX. SESSION 1886-7.

The ANNUAL MEETING of the Members was held on Tuesday, October 5th, 1886, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, H. M. ORMEROD, Esq., F.G.S., In the Chair.

The President called upon the Hon. Secretary, Mr. MARK STIRRUP, to read the report of the Council:—

REPORT OF THE COUNCIL

FOR SESSION 1885-86.

The Council, in presenting their report for the past year, are glad to be able to record a Session of good average work and prosperity.

Both objects of the Society's operations, the one relating to the Coal-Mining industry, as well as that of pure Geology, have been fully represented in the subjects brought before the meetings.

The papers read have shown great care in their preparation and have induced valuable discussion.

The papers on "Accidents in Mines and their Prevention," the discussions on the numerous improvements in Safety-Lamps, as well as the feasibility of the Electric Lighting of Mines, and the possible perfection of a Miner's Electric lamp; all bear witness to the attention that is now being paid to the welfare of the mining population both by employers and managers.

The experiment of Evening meetings of a social character at the Owens College Museum has been continued with fairly gratifying results; nevertheless, the Council would be pleased to find that a larger number of the members availed themselves of the occasion of becoming acquainted with the valuable collections therein stored.—The members are again reminded of the privilege they have of free access to the Geological Museum on all days of the week except Monday, and that the public have the right of free admission on Tuesdays, Thursdays, and Saturdays.

On the 28th of August, a successful and interesting excursion was made to the district of Saddleworth, which afforded an opportunity to the members of examining some of the Lower Coal Measures, and the Millstone Grit Rocks of that locality.

The inspection of the reservoirs belonging to the Corporation of Oldham in the Piethorn and Denshaw valleys was also included in the programme, which was fully carried out under the able guidance and leadership of one of our members, Mr. William Watts, F.G.S., the resident manager of the waterworks.

By the appointment of J. S. Martin, Esq., to the post of H.M. Inspector of Mines for South Wales, the Society loses one of its most important officers, and while the Council rejoice at his well earned advancement, they cannot but regret the consequent loss to the Society of his valuable

services, which have been so ungrudgingly given and often at great personal inconvenience during a period of ten years.

The financial position of the Society still continues sound and satisfactory as will be seen from an examination of the Treasurer's Balance Sheet; all claims upon the Society's income, so far as known, having been met.

The Treasurer has, under the direction of the Council, purchased one hundred pounds stock in the Lancashire and Yorkshire Consolidated four per cent Preference Stock at a cost of £113 7s. 6d., thus bringing our investments up to £900 stock. The total receipts for the Sessional year 1885-6 from all sources were £221 5s., and the disbursements on the general account to £202 18s. 4d. which latter include some exceptional items, such as that of a new bookcase, the binding of volumes of transactions, &c.

The LIBRARY has continued to receive, during the year, a number of valuable additions, both as presentations and exchanges, among the most important of which may be considered the Survey Reports of the United States and of Canada, the former of which are generally bountifully illustrated and most liberally distributed. Several purchases of valuable Books of Reference have also been made, among which may be named:—

Dr. Ure's Dictionary of Arts, Manufactures, and Mines. 4 vols.

Earthquakes of Ischia, by H. J. Johnston-Lavis.

Physical Geology and Palæontology, by Professor Seeley, F.R.S.

Stratigraphical Geology and Palæontology, by Robert Etheridge, F.R.S.

Accidents in Mines, by A. R. Sawyer.

In consequence of several applications from private persons and Societies for some of the early "Parts" and

complete sets of the "Transactions," either for purchase or exchange, it was decided in December last to bind up as far as possible some 20 sets each of the earlier volumes. Notwithstanding the reprinting two years ago of several of the Parts which were out of print, it was found on the examination of the stock that some others were exhausted. It was not thought advisable, however, to recommend any further large expenditure on reprinting, and the volumes have, therefore, been made up as complete as the circumstances allowed.

The following volumes are in differing degrees imperfect, viz., Vols. 2, 3, 5, and 6. Altogether 173 volumes of Transactions have been bound, and the present occasion suggests itself as a favourable one to any member wishing to complete his series of the Transactions, as it is probable that the early volumes will soon become scarce.

In the last Annual Report attention was drawn to the incomplete state of the Library Catalogue, owing to the continual additions to the Library having been omitted to be entered into the interleaved copy. A manuscript catalogue has been prepared, after much tedious labour, but it will be necessary, before a new one is printed, that stock be taken of the books, and compared with the manuscript; for this purpose some expenditure will be required.

It is desirable also that early steps be taken to bind up a large number of serial works, such as JOURNALS and TRANSACTIONS of Corresponding Societies, so as to place the Library in good condition for the use and easy reference of the members.

During the ensuing Session it is proposed to hold, as usual, two meetings in Wigan, and the Council consider it incumbent upon the local members to render these meetings as valuable as those held in Manchester, by providing papers, and by taking a hearty interest in the discussions.

The Session 1885-6 has closed without alteration in the number of members upon the register.

The Society has lost by death during the year two members, one a Life-Member in the person of the much-respected Sir Humphrey de Trafford, Bart., who, though not taking any active part, maintained his interest in the Society.

Two members have resigned, and the names of five have been removed from the list, in consequence of default in the payment of their subscriptions.

Eight new ordinary members and one Honorary Member, Professor W. C. Williamson, LL.D., F.R.S., have been elected, making a total of 215, consisting of 17 Honorary, 7 Life, and 191 Ordinary Members.

Mr. STIRRUP also read the statement of the Treasurer's Accounts:—

GENERAL STATEMENT.

	£	s.	d.		£	s.	d.
To Arrears left 1885.	19	0	0	By Subscriptions received to September, 1886	181	0	0
,, Members as by Account	201	0	0	,, Members struck off.	4	0	0
,, New Members ..	8	0	0	,, Members dead or discontinued	15	0	0
				,, Arrears remaining..	28	0	0
	£228	0	0		£228	0	0

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

1885-6.	Abstract of Receipts.	£	s.	d.
Oct. 1.	To Balance brought down, 1885	106	10	1
	,, Birkenhead Dividends	23	4	0
	,, Lancashire and Yorkshire Dividends	11	12	0
	,, Sale of Transactions	4	19	0
	,, Subscriptions	177	0	0
	,, Arrears	4	0	0
	,, Bank Interest	0	10	0
		£327	15	1
Oct. 1.	To Balance brought down	£6	14	3

1885-6.	Abstract of Payments.	£	s.	d.
Oct. 1.	By Library	17	3	1
	,, Transactions	77	15	0
	,, Reporter	11	16	0
	,, Circulars, Stationery, &c.	19	8	9
	,, Postages and Carriage of Parcels	23	6	0
	,, Meetings—Extra Expenses	1	0	0
	,, Collectors' Commission	9	1	0
	,, Rent, &c.	30	0	0
	,, Attendance, Library	2	10	0
	,, Insurance	0	12	6
	,, Repairs, Furniture	12	13	6
	,, Purchase of Stock	113	7	6
	,, Solicitor's Charges	2	7	6
		£321	0	10
	,, Balance carried down	6	14	3
		£327	15	1

The Investments consist of £600 Four per Cent. Guaranteed Stock of the Birkenhead Railway, and £300 Lancashire and Yorkshire Consolidated Four per Cent. Preference Stock, in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct, 19th October, 1886.

ALFRED PILKINGTON,
JAMES ATHETON, } Auditors.

HENRY M. ORMEROD, Treasurer.

1st October, 1886.

It was moved, seconded and carried unanimously that the report of the Council and the Treasurer's statement (the latter subject to audit) be approved and entered on the minutes.

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE MEETINGS DURING THE SESSION 1885-6.

1885.

October. Brongniart, Chas., F.E.S. "The Fossil Insects of the Primary Group of Rocks."

November. Ormerod, H. M., F.G.S. "Footprints in Sandstone Flag."

Greenwell, G. C., F.G.S. "Geology of the Island of Jersey."

Garforth, W. E. "On Working Coal by Long Wall."

December. Stirrup, Mark, F.G.S. "Fossils from the Palæozoic Rocks of America (Indiana)."

Burrows, J. S. "Accidents in Mines and their Prevention. Part 2."

Martin, J. S., F.G.S. "On the Effect of Atmospheric Changes upon the Development of Fire Damp."

1886.

January. Leech, A. H. "Screening Arrangements at Brinsop Hall Collieries."

Wild, George. "On Sinking with a Tail Rope."

Winstanley, George. "On a Gauzeless Safety Lamp."

Clifford, William. "Testing a New Safety Lamp."

26. Ward, Thomas. "On Rock Salt." (Given at Owens College.)

February. Wild, George. Section through Middle Coal Measures at Bardsley Colliery, and an interesting Discovery of Calamites."

March.	Stirrup, Mark, F.G.S. British Association Meeting, Aberdeen. Delegate's Report.
	Clifford, William. "Description of New Safety Lamp."
	Connolly, Thomas. "The Progress of Electric Lighting in Mines."
April.	Williamson, W. C., F.R.S. "Structure of Calamites."
May.	Hall, Henry. "On the fracture of Safety Lamp Glasses."
	Clarke, C. F. "Notes on Brown's Safety Catch for Wire Rope Guides."
June.	Mercier, M. "On a New Safety Lamp."
	Dawkins, W. B., M.A., F.G.S. "On the Formation of Agates."

NEW HONORARY MEMBER.

W. C. Williamson, Prof., LL.D., F.R.S.

NEW ORDINARY MEMBERS.

Clifford, Wm.	Newton, C. E.
Dugdale, Crispin	Turton, Jno. Junr.
Knowles, Robert	Uttley, J. F.
Mawson, R. B.	Wallwork, John.

MEMBERS DECEASED.

Green, George	Sir Humphrey de Trafford, Bart.
Park, James	

MEMBERS RESIGNED, &c.

Hewlett, W. H.	Percy, C. M.
Penman, J. H.	Still, F. M.
Pennington, A. S.	Waddington, H.
	Worthington, H.

APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1885–86.

Belfast Natural History and Philosophical Society.—Report and Proceedings for Session 1884-5. *From the Society.*

Bristol Naturalists' Society.—Proceedings, Part 1, Vol. V. *From the Society.*

Chester Society of Natural Science.—Proceedings, No. 3, and 15th Annual Report. *From the Society.*

Chesterfield and Derbyshire Institute of Engineers.—Transactions. Part 5, Vol. XII.; Parts 3-6, Vol. XIV.; Parts 1-2, Vol. XV. *From the Institute.*

Cornwall.—Transactions of the Royal Geological Society of. Part 8, Vol. X. *From the Society.*

Cornwall.—Royal Institution of. Journal, Part 4, Vol. VIII. *From the Council.*

Cornwall.—Mining Association and Institute of Cornwall. Transactions. Part 2, Vol. 1. *From the Council.*

Dublin.—Royal Dublin Society.—

Scientific Proceedings. Parts 7-9, Vol. IV.; Parts 1-2, Vol. V.

Scientific Transactions, Vol. III., Series 2, Nos. 7-10. *From the Society.*

Royal Geological Society of Ireland. Journal, Part 3, Vol. VI., N.S., 1882-84; Part 1, Vol. VII., N.S., 1884-85. *From the Society.*

Edinburgh Royal Physical Society.—Proceedings, Session 1884-85. *From the Society.*

Glasgow Natural History Society.—Proceedings and Transactions. Part 2, Vol. I., 1884-85. Index to Proceedings, Vols. I.-V. *From the Society.*

Hertfordshire Natural History Society and Field Club.—Transactions. Parts 5-9, Vol. III. *From the Society.*

Leeds Philosophical and Literary Society.—Annual Report, 1885-6. *From the Society.*

Leeds Geological Association.—Transactions. Part 1, 1883-85. *From the Association.*

Leicester Literary and Philosophical Society.—Report of Council for 1885. *From the Society.*

Liverpool Geological Association.—Transactions. Vol. IV., Session 1883-84; Vol. V., 1884-85. *From the Association.*

Liverpool Science Students' Association.—Proceedings, 1884-85. *From the Association.*

London Geological Society.—Quarterly Journal. Nos. 165, 166, 167, Vol. XLII. *From the Society.*

London Geologists' Association.—Proceedings. Nos. 3-5, Vol. IX. *From the Association.*

London Geological Magazine.—Nos. 257-267. *Purchased.*

London.—Institution of Mechanical Engineers.—Proceedings. Nos. 4-5, 1885; Nos. 1-2, 1886. General Index to Proceedings, 1874-84. *From the Institution.*

London.—Iron and Steel Institute.—Journal. Vol. II., 1885; No. 1, 1886. *From the Institute.*

London.—Palæontographical Society.—Vol. XXXIX., 1885. *Purchased.*

London.—Royal Institution of Great Britain.—Proceedings, No. 79, Vol. XI., Part 2. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 239-241, Vol. XXXIX. Parts 242 to 246, Vol. XL. *From the Society.*

Manchester Association of Employers, Foremen, and Draughtsmen. Thirtieth Annual Report, 1885. Three Pamphlets. *From the Association.*

Manchester Literary and Philosophical Society.—Memoirs, Vol. VIII. Third series. Proceedings, Vols. 23-24. *From the Society.*

Manchester Field Naturalists' and Archæologists' Society.—Report and Proceedings, 1884 and 1885. *From the Society.*

Manchester Microscopical Society.—Annual Report, 1885. *From the Society.*

Midland Institute of Engineers.—Transactions. Parts 78-82, Vol. X. *From the Council.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers.—Transactions. Part 6, Vol. XXXIV.; Parts 1-3, Vol. XXXV. *From the Institute.*

Scotland.—Mining Institute of Scotland.—Transactions. Parts 4-9, Vol. VII., and Parts 1-4, Vol. VIII. Report of Mining Exhibition, Glasgow, 1885. *From the Council.*

South Wales Institute of Engineers.—Proceedings. Parts 4 and 6, Vol. XIV. *From the Institute.*

Warwickshire Naturalists' Field Club.—Proceedings, 1885. *From the Club.*

Yorkshire Geological and Polytechnic Society.—Proceedings. Part 1, Vol. IX., N.S. *From the Society.*

Alpine Winter in its Medical Aspects. By A. T. Wise, M.D. *From the Author.*

Catalogue of Western Scottish Fossils. *From the Geological Society of Glasgow.*

Organization of the Fossil Plants of the Coal Measures. Parts 6-12. By Professor W. C. Williamson, LL.D., F.R.S. *From the Author.*

Erratics in the Boulder Clay of Cheshire. Pamphlet by Charles Ricketts, M.D., F.G.S. *From the Author.*

On Indented Pebbles in the Bunter Sandstone. Pamphlet by Charles Ricketts, M.D., F.G.S. *From the Author.*

Quartzite Boulders in a Coal Seam in Leicestershire. Pamphlet by W. S. Gresley, F.G.S. *From the Author.*

On Fossiliferous Hæmatite Nodules in Permian Breccias, Leicestershire. Pamphlet by W. S. Gresley, F.G.S. *From the Author.*

Geology of Coasts adjoining Rhyl, Abergele, and Colwyn. By Aubrey Strahan, M.A. (Geological Survey Memoir.) *From the Author.*

Glaciation of South Lancashire, Cheshire, and Welsh Border. By Aubrey Strahan, M.A. *Pamphlet from Author.*

Physical Geology and Palæontology. By Professor Seeley, F.R.S. *Purchased.*

Stratigraphical Geology and Palæontology. By Robert Etheridge, F.R.S. *Purchased.*

Dr. Ure's Dictionary of Arts, Manufactures, and Mines. 4 Vols. *Purchased.*

Earthquakes of Ischia. By H. J. Johnston-Lavis. *Purchased.*

Accidents in Mines in the North Staffordshire Coalfield. By A. R. Sawyer. Two Copies. *One presented by the Author and one purchased.*

Ninth, Tenth, and Eleventh Reports of Committee on Circulation of Underground Waters. *From C. E. de Rance, F.G.S.*

Accidents in Mines: Final Report, 1886. *Blue Book from Her Majesty's Commissioners.*

What I believe. By Leon Tolstoi. *Presented by the Author.*

Annual Reports, from the Committees.

Cambridge University.—20th Annual Report of Museum and Lecture Rooms Syndicate.

Devon and Exeter Albert Memorial Museum.—16th Annual Report of Committee. 1886.

Dulwich College Science Society.—7th Annual Report. 1884-5.

Dundee Free Library. 1885.

Liverpool Free Library and Museum.—33rd Annual Report. 1886.

Manchester.—Owens College.—Calendar. 1886-7.

Oxford University Museum.—Catalogue, Radcliffe Library. 1885.

Salford Museum, Libraries and Parks.—37th Annual Report. 1884-5.

Wigan Free Public Library.—8th Annual Report. 1886.

Canada and U.S. America.

Canada.—Canadian Institute, Toronto.—Proceedings. Nos. 3-4, Vol. III., 3rd Series. *From the Institute.*

Canada.—Geological Survey of Canada. Contributions to Canadian Palæontology. Part 1.

Report on Invertebrata of Laramie and Cretaceous Rocks. By J. F. Whiteaves, F.G.S.

Summary Report of Geological and Natural History Survey of Canada, to 31st December, 1885.

From A. R. C. Selwyn, F.R.S., Director of the Survey.

U.S.A., Cambridge.—Harvard College.—25th Annual Report of the Curator of the Museum of Comparative Zoology. *From Alexander Agassiz.*

U.S.A., Harvard College.—Bulletin of the Museum of Comparative Zoology. Nos. 2-5, Vol. XII. *From Alexander Agassiz.*

U.S.A., New York. — American Museum of Natural History. Bulletin No. 6; Vol. I. Annual Report of the Trustees, 1885-6. *From the Trustees.*

U.S.A., New York. — American Institute of Mining Engineers. List of Members and Rules, November, 1885. Transactions, Vol. XIV. *From the Institute.*

U.S.A., Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2 and 3, 1885. Part 1, 1886. *From the Academy.*

U.S.A., Philadelphia.—Journal of Franklin Institute. Nos. 719-720, Vol. CXX. Nos. 721-729, Vol. CXXI. *From the Institute.*

U.S.A., Washington.—Smithsonian Institution.—Annual Report for 1883. Annual Report for 1884. *From the Board of Regents.*

U.S.A., Washington.—United States Geological Survey.

4th Annual Report, 1882-83, by J. W. Powell, Director.

5th Do. do. 1883-84.

Monograph: Vol. VIII., Palæontology of the Eureka District, by C. D. Walcott.

Monograph: Vol. IX., Brachiopoda and Lamellibranchiata of the Raritan Clays, &c., by R. P. Whitfield.

Bulletin. Nos. 7-26.

Mineral Resources of United States, 1883-4, by A. Williams, Junr. *From the Director of the Survey.*

U.S.A., Washington.—Annual Report of the Comptroller of the Currency, December 1st, 1885. *From the Comptroller.*

Australia.

Sydney.—Royal Society of New South Wales. Journal and Proceedings. 1884. President's Address, 1886, by Prof. Liversidge. *From the Society.*

List of Members of Geological Society of Australasia.

Victoria.—Gold Fields of. Reports of Mining Registrars. September and December, 1885; March, 1886. *From the Government.*

Victoria.—Annual Report of Mines and Water Supply for 1886.

Victoria.—Report of Trustees of the Public Library, Museum, &c., for 1884.

Victoria.—Mineral Statistics of 1884. *From the Government.*

FOREIGN.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 3-4, Band XXXVII. Heft 1-2, Band XXXVIII. *From the Society.*

Brussels.—Société Malacologique de Belgique. Annales. Vols. I.—IX., Vols. XV.—XX. Procès-Verbaux, January to December, 1885, Vol. XIV., January to July, 1886. *From the Society.*

Buenos Ayres.—Censo Escolar Nacional. Vol. I. Two copies. Censo Escolar Nacional, 1883-84. Tome XI. Two copies. *From the Government.*

Christiania.—Royal University of Norway: Lakis Kratere og Lavastromme, by Amund Helland. *From the University.*

Dresden.—Festschrift der N. G. Isis in Dresden, May, 1885. Sitzungsberichte der Naturwissenschaftlichen Gesellschaft Isis in Dresden. January to June, 1886. *From the Society.*

Halle, a/S.—Vereins fur Erdkunde. Mittheilungen, 1885. *From the Society.*

Lausanne: Bulletin de la Société Vaudoise des Sciences Naturelles. No. 93, Vol. XXI. *From the Society.*

Leipzig—Sitzungsberichte der Naturforschenden Gesellschaft zu Leipzig, 1885. *From the Society.*

Leipzig.—Systematische Ubersicht der fossilen Myriopoden, Arachnoideen und Insekten, by S. H. Scudder.

Liége.—Notes sur les Levés Géologiques. Pamphlet, by E. Van den Broeck. *From the Author.*

Lille.—Société Géologique du Nord. Annales XII., 1884-5. *From the Society.*

Paris.—Revue de le Legislation des Mines. Monthly. *Purchased.* Les Insectes Fossiles des Terrains Primaires. Pamphlet. *Presented by the Author, M. Charles Brongniart.*

Pisa.—Atti della Società Toscana di Scienze Naturali. Memorie. Fasc. 2, Vol. VI., Vol. VII., Processi Verbali, June, 1885, to January, 1886, May 2nd, 1886. *From the Society.*

Roma.—Atti della Reale Accademia dei Lincei. Memorie. Vols. XVIII.—XIX., Series 3. Vol. II., Series 4. Rendiconti. Fasc. 21-28, Vol. I., 1885. 1-14, Vol. II., Fasc. 1-4, Vol. II. *From the Academy.*

St. Petersbourg.—Academie Impériale des Sciences. Bulletin. Parts 2-3, Tome XXX.; Part 1, Tome XXXI. Memoires. Parts 14-18, Tome XXXII.; Tome XXXIII., Parts 1-8; Tome XXXIV., Parts 1-3. *From the Academy.*

St. Petersbourg. — Institut des Mines. Comité Géologique. Mémoires :

Vol. I., No. 4. Aperçu Géologique du District de Lipetzk, par J. Mouschketoff.

Vol. II., No. 2. Carte Géologique Génerale de la Russie. Feuille 93. Partie Occidentale.

Vol. II., No. 3. Les Ammonites.

Vol. III., No. 1. Die Fauna des Untern Devon am West-Abhange des Urals.

Bulletins : Parts 5-10, 1885. Nos. 1-6, 1886.

Bibliothéque Géologique de la Russie. 1885. *From the Minister of Domains.*

Wien.—Annalen des K. K. Naturhistorischen Hof Museums. Nos. 1-2, Band I.

BOOKS PURCHASED, 1885-6.

Geological Magazine.

Physical Geology and Palæontology. By Professor Seely.

Stratigraphical Geology and Palæontology. By R. Etheridge.

Dr. Ure's Dictionary of Arts, Manufactures, and Mines. 4 vols.

Earthquakes of Ischia. By H. J. Johnston-Lavis.

Accidents in Mines in North Staffordshire Coal-Field. By A. R. Sawyer.

Palæontographical Society's Monograph. Vol. XXXIX. 1885.

Revue de la Legislation des Mines. Paris.

Societies with whom the Society Exchanges its Transactions, and Institutions and Journals to whom a Copy is sent Free.

I.—England.

London .....British Museum.
Geological Society.
Geological Survey.
Geologists' Association.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute.
Royal Institution.
Royal Society.
Society for Psychical Research.

Manchester .....Association of Employers, Foremen, and Draughtsmen.
Field Naturalists' Society.
Free Library.
Literary and Philosophical Society.
Owens College.
Salford Royal Museum and Library.
Scientific Students' Association.

Barnsley.....Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.

Bristol .....Naturalists' Society.

Cambridge .....Geological Museum, University.
University Library.

Chester .....Society of Natural Science.

Chesterfield.....Institute of Mining Engineers (in bound vols.)

Cornwall.....Royal Geological Society, Penzance.
Royal Institution, Truro.

Dudley .....South Staffordshire and East Worcestershire Institute of Mining Engineers.

Essex .....Essex Field Club, Stanley Road, Woodford.

Exeter .....Albert Memorial Museum.

Halifax .....Geological and Polytechnic Society.

Leeds .....Philosophical and Literary Society.
Leicester.....Literary and Philosophical Society.
Liverpool .....Free Library and Museum.
Geological Association.
Geological Society.
Newcastle-on-Tyne.Institute of Mining and Mechanical Engineers.
Norwich .....Geological Society.
Oxford .....Bodleian Library.
Radcliffe Library.
North Shields....Public Free Library.
Tuckingmill, Camborne ..Mining Association and Institute of Cornwall.
Stoke-on-Trent ..North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea .....South Wales Institute of Mining and Mechanical Engineers.
Warwick.....Natural History Society.
Watford, Herts ..Natural History Society and Field Club.
Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee .....Free Library and Museum.
Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.
Glasgow .....Geological Society.
Natural History Society.
Hamilton .....Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast .....Natural History Society.

IV.—Australia.

Melbourne .....Public Library of Victoria.
Sydney .....Free Public Library.
Royal Society of New South Wales.
Newcastle .....John Mackenzie, F.G.S.

V.—Canada.

Hamilton .....Hamilton Association.
Montreal.....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director.)
M'Gill College (Principal, J. W. Dawson, F.G.S.)
Toronto .....Canadian Institute.

VI.—United States.

Boston, U.S. ....Free Library.
Columbus, U.S. ..Ohio, Geological Survey of (Professor Edward Orton, State Geologist).
Indiana, U.S.....Department of Geology and Natural History (John Collett, State Geologist).
*Indianopolis, U.S.*E. T. Cox, State Geologist.
Newhaven, U.S...Professor O. C. Marsh, F.G.S.
New York, U.S...American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).
New York .....American Museum of Natural History, Central Park.
*Philadelphia, U.S.*Academy of Natural Sciences.
Franklin Institution.
Washington, U.S...Department of the Interior U.S. Geological Survey.
Smithsonian Institution.
Wyoming, U.S. ..Historical and Geological Society.

VII.—Foreign Societies.

Berlin .....Deutsche Geologische Gesellschaft.
Brussels .....Société Royale Malacologique de Belgique.
Buenos Ayres....Officiana Nacional de Commercie.
Calcutta .....Geological Survey of India.

Christiania.....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gesellschaft Isis.

Halle, A.S. ....Verein fur Erdkunde.

Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Lausanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Lille .....Société Géologique du Nord.

Pisa .....Società Toscana di Scienze Naturali.

Rio de Janeiro ..Museo Nacional.

Rome .....Reale Accademia dei Lincei.

St. Petersburg....Académie Impériale des Sciences.

Institut des Mines. Comité Géologique.

Turin .....Académie Royale.

VIII.—Scientific Journals, &c.

Geological Magazine, Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review, Revue de la Legislation des Mines, Paris. (M. Delecroix, 7, Place du Concert à Lille.)

The President said the next business was to elect the officers for the ensuing year. The Council had gone through the list of attendances, and they had now to present a list of gentlemen whom they recommended for election.

The list was then read over, and no objection being raised, nor other names proposed, it was moved, seconded, and carried unanimously that the following gentlemen be elected officers of the Society for the Session 1886-7 :—

President:

PROFESSOR W. BOYD DAWKINS, M.A., F.R.S., F.G.S., F.S.A.

Vice-Presidents:

R T. BURNETT, F.G.S.
HENRY HALL, H.M.I.M.
WM. WATTS, F.G.S.
GEORGE WILD.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S.
G. W. ORMEROD, F.G.S.
JOSEPH DICKINSON, F.G.S.
ANDREW KNOWLES.
G. C. GREENWELL, F.G.S.
JOHN KNOWLES, M.Inst.C.E.
R. CLIFFORD SMITH, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. K. SHUTTLEWORTH, BART.
GEORGE GILROY, M.Inst.C.E.
EDWARD PILKINGTON, J.P.
H. M. ORMEROD, F.G.S.

Hon. Treasurer:

HENRY MERE ORMEROD, F.G.S.

Hon. Secretaries:

MARK STIRRUP, F.G.S.
JOHN S. BURROWS.

Other Members of the Council:

W. S. BARRETT.
CHARLES HARDWICK.
G. H. HOLLINGWORTH, F.G.S.
C. G. JACKSON.
CLEGG LIVESEY.
R. B. MAWSON.
GEORGE PEACE.
JAMES RADCLIFFE.
JAMES TONGE, F.G.S.
J. TURTON, JUN., H.M.I.M.
ROBERT WINSTANLEY.
H. A. WOODWARD.

Hon. Auditors:

ALFRED PILKINGTON.
JAMES ATHERTON.

REPORT OF THE SOCIETY'S DELEGATE TO THE MEETING OF THE BRITISH ASSOCIATION AT BIRMINGHAM, 1886.

The Hon. Secretary (Mr. Mark Stirrup), who represented the Society at Birmingham, reported that two Conferences of the Delegates were held on the 2nd and 7th September, both meetings being well attended, about 20 to 25 delegates being present. At the first meeting, presided over by Professor A. W. Williamson, F.R.S., the report to the Council of the Corresponding Societies' Committee, stating the work done at Aberdeen, was presented. (For particulars of Aberdeen meeting, see Delegate's Report, page 466, Part 17, Vol. 18.) Mr. Stirrup read from this report the following paragraphs, which have reference to the co-operation of local societies in the various scientific investigations carried on by the British Association, and also the duties of the Delegates, who are the recognized means of communication between the committees of the British Association and their corresponding societies.

"That each Delegate should do his best to interest the members of his Society, and, if thought desirable, the Society itself, in the subject of investigation, and should send to his correspondent the names and addresses of such persons in his neighbourhood as might be likely to render willing and effectual help."

"The Committee have now to point out that, although 39 Societies were appointed as Corresponding Societies, only 23 of them nominated delegates. Of the 23 delegates only 11 were present at the final meeting to hear the explanations of the gentlemen who attended for the purpose of making them, and of placing themselves in personal communication with the several delegates. The Committee feel sure that the delegates who failed to attend the Conference had not realised the character of the engagement into which they had entered, and

that they must have erroneously regarded their title and privileges as purely honorary, and their duties as sinecures. The Corresponding Societies' Committee desire it to be clearly understood that such is not the case, as the work entrusted to the delegates is real and important. The position of each delegate is that of a person of scientific influence in his own neighbourhood, who, by the acceptance of his title and its privileges, pledges himself to act as a friendly intermediary between those committees of the British Association who are occupied with local investigations and the local scientific men who are known to him. It is his duty to make himself well informed of the nature of the proposed enquiries sanctioned by the British Association, as personally explained by the representatives of the respective committees, and to qualify himself as far as possible for the honourable post of local correspondent. It is in return for the prospect of this very valuable assistance that the grant is made to each delegate of being a member of the General Committee, and the privilege accorded to the Society which he represents of publication in the reports of the British Association of a catalogue of its local investigations. Hereafter the Corresponding Societies' Committee will take into consideration the advisability of not recommending for re-election those Societies whose delegates fail to attend the meeting of the Conference without adequate explanation."

After the reading of the Report the Chairman invited the Delegates to offer suggestions or make proposals as to the kind of scientific work that could be taken up by local societies. The Chairman suggested the subject of insects noxious to vegetation as one well worthy of attention.

Another suggestion was, the systematic investigation into the early evidences of man in Great Britain.

A discussion arose as to the relationship of Delegates to the various sectional committees of the British Association, and it was resolved that each Delegate should be proposed on to the committee of that section with which he preferred to be identified.

The second Meeting was held under the presidency of Professor W. B. Dawkins, F.R.S., when suggestions were

again offered as to subjects of investigation which could be assisted by local scientific societies.

Mr. C. E. DE RANCE, F.G.S., deputed by Section C, reported how help could be given to the inquiries undertaken by the committees with which he was connected with regard to Underground Water and Sea Coast Erosion, and Dr. H. W. CROSSKEY followed, as representing the Erratic Block Committee, and gave some details as to the information sought by his committee, viz., the position of boulders, whether lying in drift or exposed on the surface, height above sea, lithological characters, and probable origin.

Professor HILLHOUSE, representing Section D, suggested the appointment of a committee to gather information with regard to Local Public Museums, their contents and mode of management, so as to devise some scheme to render them more efficient and useful.

Professor HILLHOUSE also recommended the subject of the preservation of local plants, as a subject worthy of the attention of local societies of naturalists.

Section H was represented by Dr. GARSON, who offered suggestions as to the manner in which local societies could give assistance in exploration and researches for the evidences of Pre-historic man. Reference was made to the dangerous state of Stonehenge, and the necessity for some legislation with regard to ancient monuments.

The foregoing is a brief report of the principal matters brought before the two Conferences, and your delegate submits them to the consideration of the Society, and should any members in their individual capacity desire to aid any of the investigations referred to, or to initiate new ones, he will be glad to further them by any information as to form of procedure or give any help in his power.

NEW MEMBERS.

The following gentlemen, whose names had been previously submitted to the members, were duly balloted for and unanimously elected:—Honorary member, Mr. Joseph S. Martin, H.M. Inspector of Mines, Swansea; Ordinary members, Sir Humphrey F. De Trafford, Bart., Trafford Park; Mr. Guy Wood, 71, King Street, Manchester; and Mr. Henry Bramall, Pendleton Colliery, Manchester.

VOTES OF THANKS.

A cordial vote of thanks was given to H. M. Ormerod, Esq., the retiring President, for the able way in which he had conducted the affairs of the Society during the past year. The same compliment was paid to the Hon. Secretaries, which concluded the business of the Annual Meeting.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey-, Bart, M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M. A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart, M.P.
1861-2-3, 77-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S
1878-9	Forbes, John Edward, F.G.S
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.
1885-6	Ormerod, Henry Mere, F.G.S.

LIST OF MEMBERS.

OCTOBER, 1886.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Withins Lane Colliery, Radcliffe.
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Rishton Colliery, Blackburn.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton. *Hon. Auditor.*
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1885	Barker, Israel, 319, Whit Lane, Pendleton.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool. *Member of Council.*
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1877	Beswick, James, Shakerley Collieries, Tyldesley.
1885	Bickerton, Charles W., Hazel Grove, near Stockport.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Baxenden, Accrington.
1878	Bradford, The Right Hon. the Earl of, Weston Park, near Shifnal.

Year of Election.	
1886	Bramall, Henry, Pendlebury Colliery, Manchester.
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 124, Rue Terre Neuve, Brussels.
1877	*Brongniart, Charles*, F.E.S., 8, Rue Guy-de-la-Brosse, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm. Speakman, Summerby, 106, Eccles Old Road, Eccles.
1859	Bryham, William, J.P., Ince Hall, Wigan.
1881	Bryham, William, jun., Douglas Bank Colliery, Wigan.
1882	Burnett, R. T., F.G.S., Cresswell Grove, Albert Park, Didsbury. *Vice-President.*
1879	Burns, Thomas, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Yew Tree House, Atherton, near Manchester. *Hon. Secretary.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, Henry, Surveyor, St. Helens.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1886	Clifford, William, Norton Woodseats, Sheffield.
1882	Cockson, Charles, King Street, Wigan.
1878	Cooke, Charles, Twycross, Atherstone, Leicestershire.
1859	*Coulthart, John Ross, F.R.S., Lit., F.S.A., Scot., Greenlaw Park, Castle Douglas, Kirkcudbrightshire, N.B.
1878	Cowburn, Henry, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1882	Cunliffe, James, Duxbury Park Colliery, Chorley.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *President.*

Year of Election.	
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley, Liverpool.
1882	Devonport, John, Chamber Collieries, Oldham.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1885	Dugdale, Crispin, 5, North Road, Cloughfold, Rossendale.
1880	Duncan, William, M.D., Prospect House, Tyldesley.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Old Hall, near Manchester.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.* The Cedars Methley, Leeds.
1838	*Enniskillen, The Right Hon. the Earl of*, F.R.S., Florence Court, Fermanagh.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1873	Garforth, W. E., Colliery Offices, Normanton.
1884	Garside, Sampson, Denton and Houghton Collieries, Denton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Woodlands, Parbold, Wigan, *Past-President.*
1882	Glover, B. B., Haydock, near St. Helens.

Year of Election.	
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1882	Gresley, W., Stukeley, F.G.S., Overseal, Ashby-de-la-Zouch.
1863	Greenwell, G. C., F.G.S., Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, junr., Ashton Moss Colliery, Audenshaw, Manchester.
1879	Gregson, Edward, 11, Chapel street, Preston.
1883	Greensmith, T., Moston Colliery, Failsworth, Manchester.
1880	Grimke, Theodore Drayton, Golborne Hall, Newton-le-Willows.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1879	*Guibal, Theophile*, Professeur d'Exploitation des Mines, Mons, Belgium.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot, *Vice-President.*
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester. *Member of Council.*
1880	Hargreaves, John, Collyhurst Paper Mills, Manchester.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1882	Heathcote, William, Farnworth, near Bolton.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester.
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1883	Hewitt, John R., Mining Engineer, Derby.
1880	Heys, James, Ince Hall Collieries, Wigan.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.

Year of Election.	
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, Wigan Coal and Iron Company, Wigan.
1885	Hindley, C.E., Clifton Road, Eccles.
1878	Holden, Charles H., Mawdsley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., Haworth's Buildings, Cross Street, Manchester. *Member of Council.*
1884	Howatt, Andrew, 25, Mill Street, Ancoats, Manchester.
1878	Howell, John, Astley, near Manchester.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1880	Hulton, W. W. B., J.P., Hulton Park, near Bolton.
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester. *Member of Council.*
1875	Jackson, J., 5, Wood Street, Bolton.
1880	Jackson, William, 75, Broadway Street, Oldham.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton.
1884	Johnson, M. G., Rainhill, Prescott.
1882	Johnson, William, Abram Colliery, Wigan.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1885	Kearsley, William, 115, Manchester Road, Tyldesley.
1882	Kenney, George, 11, King Street, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Ramilton, S.O. Donegal, Ireland.
1856	Knowles, Andrew, Swinton Hall, Swinton, near Manchester. *Past-President.*
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury. *Past-President.*

Year of Election.	
1882	Knowles, Israel, Ince, Wigan.
1877	Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.
1886	Knowles, Robert, Arncliffe, Cheetham Hill.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Member of Council.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G S., M.Inst.C.E., 4, Albion place, Leeds.
1884	Lyon, Edward, Ashton's Green Collieries, St. Helens, Lancashire.
1884	McAdoo, John, Colliery Manager, Hagside, Radcliffe.
1881	McAlpine, G. W., Whinney Hill Colliery, Accrington.
1873	*Martin, Joseph S.*, F.G.S., H.M. Inspector of Mines, Elton House, Walters Road, Swansea.
1883	Mather, William Penn, Iron Works, Salford.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester. *Member of Council.*
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1885	Newton, Charles Edward, C.E., Sale Bank Cottage, Sale.
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth. *Past-President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *Hon. Treasurer and Past-President.*
1874	*Owen, Sir Richard*, D.C.L., F.R.S., Sheen Lodge, Richmond Park, London, S.W.

Year of Election.	
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grange, Eccles. *Member of Council.*
1883	Peace, George Henry, Monton Grange, Eccles.
1877	Peace, Maskell W., F.G.S., Wigan.
1881	Pearson, A., Dukinfield Cottage, near Ashton-under-Lyne.
1877	Pennington, Rooke, F.G.S., 14, Acresfield, Bolton.
1878	Perrin, J. Beswick, M.R.C.S.E., F.L.S., Leigh, near Manchester.
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester. *Hon. Auditor.*
1879	Pilkington, Charles, Ashton and Edge Green Collieries, St. Helens.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Astley Deep Pit, Dukinfield. *Member of Council.*
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1882	Rigby, William, Leader's Buildings, King Street, Wigan.
1877	Robins, George J., Ashton, near Newton-le-Willows.
1884	Rogers, William, King Street, Wigan.
1884	Roscoe, James, Little Hulton, Bolton.
1882	Sacré, R. A., West Kirby, near Birkenhead.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Darcy Lever Collieries, Bolton.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.

Year of Election.	
1884	Shaw, David, Norbury Moor, near Stockport.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1884	Simpson, W. W., Church, Accrington.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	*Smethurst, William, F.G.S., 1, South John Street, Liverpool.
1838	Smith, G. F., M.A., F.G.S., Grovehurst, Tunbridge Wells.
1881	Smith, John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1881	Squire, J. B., A.Inst.C.E., 1, Sibella Road, Clapham, London, S.W.
1859	Statter, Thomas, Stand Hall, Bury.
	Stechert, G. E., 26, King William Street, Strand, London, W.C.
1880	Stirrup, Mark, F.G.S., Richmond Hill, Bowdon. *Hon. Secretary.*
1882	Stopford, T. R., Swan Lane Brick and Coal Company, Hindley Green, near Wigan.
1882	Storey, Edgar, Leigh, Lancashire.
1881	Taylor, Alfred, Norley Collieries, Wigan.
1880	Teale, William E., Fern Bank, Worsley.
1884	Toman, Daniel, Chamber Colliery, Oldham.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton. *Member of Council.*
1876	Topping, Walter, Bamfurlong Collieries, near Wigan.
1886	*Trafford, Sir Humphrey Francis De, Bart., Trafford Park, Manchester.

Year of Election.	
1885	Turton, John, jun., H.M. Inspector of Mines, 75, Manchester Road, Bolton. *Member of Council.*
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1885	Uttley, James Fielden, Glen Luna, Mayfield Road, Kersal.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, 11, King Street, Wigan.
1886	Wallwork, John, Clifton Moss Colliery, Clifton, Manchester.
1882	Wallwork, Thomas, Colliery Office, Walkden, near Bolton.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1879	Warburton, William, High Lane, near Stockport.
1885	Ward, Thomas, Northwich.
1880	Watts, William, F.G.S., Piethorne, Rochdale. *Vice-President.*
1878	Wells, Samuel B., Mining Engineer to the Bengal Coal Co., Ld., Khooldea Collieries, Giridih, India.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1884	Whitehead, John, Chorley, Lancashire.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Vice-President.*
1880	Williams, E. Leader, M.Inst.C.E., Queen's Chambers, John Dalton Street, Manchester.
1886	*Williamson, Professor W. C.*, LL.D., F.R.S., Egerton Road, Fallowfield.
1876	Winstanley, Robert, 28, Deansgate, Manchester. *Member of Council.*
1886	*Wood, Guy, 71, King Street, Manchester.
1876	Woodward, H. A., Clifton, near Manchester. *Member of Council.*
1877	Yates, T. M., Anderton Hall Colliery, Blackrod, Chorley.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any corrections or omissions in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XIX. SESSION 1886-7.

The ORDINARY MEETING of the Members was held on Tuesday, November 9th, 1886, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Professor W. BOYD DAWKINS, F.R.S., in the Chair.

NEW MEMBER.

Mr. JOHN NIELD, Longshut Lane, Stockport, was balloted for, and unanimously elected an Ordinary member of the Society.

The following are the recent additions to the Library:—

Cambridge—Report of Library Syndicate, June, 1886.

Chesterfield and Midland Counties Institution of Engineers: Transactions, Part 3, Vol. XV.—*From the Institution.*

Cornwall, Royal Institution of: Journal, Part 1, Vol. IX.—*From the Institution.*

Hertfordshire Natural History Society and Field Club: Transactions, Parts 1-3, Vol. IV.—*From the Society.*

Leicester Literary and Philosophical Society: Report of Council, 1886; Transactions, Part 1, October, 1886.—*From the Society.*

Liverpool—Geological Society: Proceedings, Part 2, Vol. V.—*From the Society.*

——— Science Students' Association: Annual Report, 1885-6.—*From the Association.*

London—Geological Magazine, October and November, 1886.—*Purchased.*

London—Geological Society: Quarterly Journal, No. 168; List of Fellows, November 1, 1886.—*From the Society.*

——— Geologists' Association: Proceedings, Nos. 6 and 7, Vol. IX.—*From the Association.*

Manchester Association of Engineers: Thirtieth Annual Report of Council, 1885, Three Pamphlets, and President's Address, October, 1886.—*From the Association.*

——— Scientific Students' Association: Report and Proceedings, 1885.—*From the Association.*

Midland Institute of Mining Engineers: Transactions, Part 83, Vol. X.—*From the Institute.*

Mining Institute of Scotland: Transactions, Part 5, Vol. VIII.—*From the Institute.*

North of England Institute of Mining and Mechanical Engineers: Transactions, Part 4, Vol. XXXV.—*From the Institute.*

South Wales Institute of Engineers: Proceedings, No. 1, Vol. XV.—*From the Institute.*

Inland Transport and Manchester Ship Canal: Reprint from *Scottish Review*, October, 1886.

Explosions in Coal Mines, by W. N. and J. B. Atkinson.—*Purchased.*

Special Report on Explosion of Fire-damp at Bedford Colliery, Lancashire, by Joseph Dickinson, F.G.S.—*From the Author.*

Canada: Catalogue of Collection of Economic Minerals of Canada, Colonial and Indian Exhibition, 1886.—*From Director of Geological Survey.*

——— Hamilton Association: Journal and Proceedings, Part 2, Vol. I., 1884-5.—*From the Association.*

Toronto, Canadian Institute: Proceedings, No. 1, Vol. IV.—*From the Institute.*

U.S.A., Cambridge, Harvard College: Museum of Comparative Zoology, No. 6, Vol. XII.; Report on Mollusca. No. 1, Vol. XIII.; Reports on Results of Dredging.—*From Alexander Agassiz.*

——— New York: American Museum of Natural History, Bulletin No. 7, Vol. I.—*From the Museum.*

——— Philadelphia: Franklin Institute, Journal, Nos. 730-731.—*From the Institute.*

——— Washington: Report upon Third International Geographical Congress and Exhibition at Venice.—*From Chief of Engineers, U.S. Army.*

Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft, XXXVIII. Band, 3 Heft, 1886.—*From the Society.*

Halle, A.S.: Mittheilungen des Vereins für Erdkunde, 1886.—*From the Society.*

Lausanne: Société Vaudoise des Sciences Naturelles, Bulletin, No. 94, Vol. XXII.—*From the Society.*

Liége: Sur le Tufeau de Ciply, par A. Rutot and E. Van den Broeck.—*From the Authors.*

Paris: Revue de la Legislation des Mines, July-August, 1886.—*Purchased.*

Pisa: Atti della Società Toscana di Scienze Naturali. Processi Verbali, July 4th, 1886.—*From the Society.*

Roma: Atti della Reale Accademia dei Lincei; Rendiconti, Fasc. 5-8, Vol. II.—*From the Academy.*

St. Petersburg: Bulletin du Comité Géologique, Nos. 7-8, and one pamphlet. Mémoire, No. 2, Vol. III.; Carte Géologique Generale de la Russie d'Europe, Feuille 139.—*From Institute of Mines.*

——— Académie Impériale des Sciences, Memoire No. 4, Vol. XXXIV., Syrische Grabenschriften. Bulletin. No. 4, Tome XXX.—*From the Academy.*

Buenos Ayres: Estadistica del Comercio y de la Navegacion de la Republica Argentina, 1885.—*From the Argentine Republic.*

Australasia: Transactions of Geological Society, Part 1, Vol. I.—*From the Society.*

——— New South Wales: Annual Report of Department of Mines for 1885.

——— Victoria: Mineral Statistics for 1885; Gold Fields of; Reports of Mining Registrars, quarter ending 30th June, 1886.—*From Minister of Mines.*

ADDRESS BY THE PRESIDENT,

(PROFESSOR W. B. DAWKINS, M.A., F.R.S.,)

"ON THE GEOGRAPHY OF BRITAIN IN THE CARBONIFEROUS PERIOD."

The PRESIDENT said: In accepting the honour which you have conferred upon me I feel that I owe a great deal to the forbearance of this Society; for, unfortunately, from the position in which I am, there are so many calls upon my time, that I have not been able, up to the present, to devote that amount of attention to the interests of the Society which I could have desired. Nevertheless, so far as I can, I will promise to do my duty, and to further the Society's interests so far as my opportunities will allow.

In an address to a Geological Society, there are two objects which may be kept well in view; one is, to bring forward something which is absolutely new and of the nature of original research; and the other is to place before the Society an outline of some special inquiry, with perhaps some fresh lights or some general observations on the results towards which that inquiry tends. Unfortunately my position this afternoon is that of one who has to undertake the second of

these tasks, rather than the first—which, of course, is of a higher and better order. I thought that, perhaps, of all subjects which I might choose to say a few words upon to this Society, none could be of greater interest than that which bears upon the physical history of the British Isles during the time when the carboniferous rocks were in process of being accumulated.

I wish first of all to call your attention to that sketch which represents the sea margin—the typical sea margin. It represents the distribution of materials at the bottom and on the margin of the sea, according to the results which have been recently placed before us in the expedition of the Challenger. You see, in due order and drawn to scale, the successive deposits which are formed at different depths. In the first place you will note that from high water mark down to about 15 fathoms we have accumulations of shingle. Beyond that we have sand reaching to a depth of about 100 fathoms; but, whether the sand has been accumulated at that depth is more than I can tell. It is very possible that that figure of 100 fathoms is really based upon the occurrence of sandbanks somewhere near the 100 fathoms line; and it may be that they were formed during some of those oscillations of level with which we are all by this time so familiar as geologists. But when we consider the distribution of the mud—the finer sediments—we find that that ranges to a considerably greater depth, to upwards of 700 fathoms; and I should feel inclined to think that, under exceptional conditions, mud from the land may be deposited even in the extreme depths of the sea. In the case of the Amazon and the La Plata, we have rivers flowing into the Atlantic at points where enormous depths come almost close to the South American shore; and there can be no manner of doubt but that the fine muddy sediments are carried down by those rivers and swept out far to sea, where in the long course of years, it may

be of centuries, they form a deposit covering the ocean bottom at the depth of 1,000 fathoms and more. But beyond the littoral mud, and ranging from the shallow seas down to depths of 2,250 fathoms, in round numbers, we have another accumulation altogether, which is analagous in its constitution to our chalk. It is calcareous, and is mainly the result of countless generations of globigerina having lived and died in that area, mingled with various shells, starfishes, and with siliceous diatoms, and polycistineæ. Then, at still greater depths, ranging from about 2,200 fathoms down to the extreme depths of the sea we have an accumulation of fine red impalpable mud. The observations taken of late years prove that these zones are clearly marked in all oceans.

We are now in a position, such as we never were before, to make out the true conditions under which the rocks of marine origin have been formed. In the first place, however, there are none of the red muds of the abysses of the sea represented anywhere in the geological record. In the second place, I would say there is no evidence whatever of the deep-sea part of the globigerina ooze being represented by any of the stratified deposits. We do find that the shore end, so to speak of the globigerina zone is represented by our chalk. With regard to the muddy deposits, the mud, of course, forms the main staple of our clays and shales, our slates and argillites, and the like. With regard to the sand, the petrified sandbanks at once reveal their proximity to land; and as to the shingle there can be no doubt whatever that we are close to the margin of the ancient shore. Indeed, we may almost fancy, when we are standing on the conglomerate or petrified shingle-beach, that we hear the dash of the breakers of seas that have disappeared countless ages ago. Let us, then, apply these principles to the inquiry which we have in hand—an inquiry into the ancient geography of this part of the world during the carboniferous age.

TABLE OF THICKNESSES.

	S. Lancashire.		Burnley. Clitheroe.	Derbyshire.	Leicester.	S. Stafford.	Flint and Denbigh.	Forest of Dean.	Ireland. Limerick. Dingle.	Ireland. Killenaule. Castle Comer.	South Wales.	Bristol.	Northumberland. Durham.	Scotland. Central Valley.	Scotland. Lothian.
UPPER CARBONIFEROUS.	feet.		feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
G.—Upper Coal measures ..	1680	2000	..	54	50	800	1000		..		1000	?	900	200	..
F.—Middle Coal measures ..	3000	4000	1017	2500	1500	200	800	2765	..		5646	4700	2000	2000	1000
E.—Lower Coal measures ..	1400	2000	2200	1000	1000	200	1000		1561		to 1000	2000	150		
D.—Millstone Grit	3500	5000	5500	2000	50	none	800	455	1000		350	950	414	400	1500
Total Thickness....	9580	13000	8717	5554	2600	1200	3600	..	2561	1700	7996	7650	3464	2600	2500
LOWER CARBONIFEROUS.															
C.—Yoredale Shale and Limestone.....	2000	4000	4675	2000	..	none	100	none	500		to 200	100	164	?	..
B.—Carboniferous Limestone	..	..	3250+	5500	25	none	1500	480	1800		900	2330	1557	?	3900
A.—Lower Carboniferous Shales, Sands, &c..	..	..	..	..	..	none	30	165	400		100	100	646	?	..
Total	..	..	7925+	7000	..	..	1630	..	2700	..	1200	2530	2367	..	3900
Total of Upper and Lower Carboniferous Strata....	11580 or 17000		16632	12554	2625+	..	5230	..	5261	1700	9196	10180	5831	..	6400

The Thicknesses in this Table are mainly based on the books, papers, and memoirs of De la Beche, Howel, Hull, Kinahan, Jukes, Lebour, Tiddeman, and A. and J. Geikie.

At the very bottom of the carboniferous rocks in this country we find, where the series is complete, the lower shale a marine mud (A) with conglomerate and sandstone. Then, above that, we have (B) the carboniferous limestone, a marine limestone, which, as we shall see presently, sheds a most important light on the ancient geography. Above that we have another series of shales familiar to most of us—the Yoredale shales (C), also marine—and above that again we have a very thick accumulation of old sandbanks, and old mud banks, the millstone grit series (D), mingled with beds of shale. I have never heard of marine shells being found in the millstone grit sandstones; but, in some places, the interbedded shales contain marine shells, though they are of exceedingly rare occurrence. When we come into the lower coal measures (E) we have marine conditions, and when we reach the middle (F) and upper (G) coal measures, we find fresh water and estuarine conditions, whilst in the upper measures we find marine conditions again. But I need hardly tell you, gentlemen, that there is no hard and fast line to be drawn between the marine and the fresh waters in the coal measure series. There is an interlacing and overlapping of marine strata containing *avicula-pecten*, *goniatites*, and the like, with fresh water beds, containing *anthracosia*. These lie in separate beds but not side by side in the same rock.

In dealing with the ancient geography of the British Isles during the carboniferous period I will divide the strata into two groups. I propose to take the lower shale (A), the carboniferous limestone (B), and the Yoredale shale (C), and to discuss the physical conditions under which these rocks were formed. Supposing we make our start in the place where the mountain limestone series is thickest—in Derbyshire. There it is no less than 5,500 feet in thickness, according to the measured geological sections, implying that it is an accumulation formed in deep water, but not, of course, in

the extreme depths to which the globigerina extends. It was formed in deep and clear water, which is proved, by the rarity of the shales, to have been for the most part free from mud. If we follow the limestone in the direction of Wales, we find in Flintshire and Denbighshire that of Derbyshire gradually grows thinner and thinner. Not only so, but there are beds of shale and sandstone associated with the limestone which prove that we are getting towards an ancient shore in that direction. If we go right away to the margin, where the lower carboniferous rocks (A) rest upon the older rocks, the lower carboniferous shore line is marked by the conglomerate and underlying sandstones and shales about 100 feet thick, resting on the Denbighshire grits of the upper silurian age. Here the limestone ranges to about 1,500 feet in thickness. There can be no doubt whatever, then, that when we are standing upon that old shingle beach we are standing upon the shore of the sea at the beginning of the carboniferous period. I have, therefore, drawn my line dividing the land from the sea at this time to the south of the Vale of Clwyd, sweeping round the Snowdon range so as to avoid Anglesea, and passing west in the direction of Dublin. It curved eastwards and southwards as far as the Clee Hills, near Ludlow, and from this point ran northwards and eastwards past Rugby to Charnwood Forest, its course further to the east being concealed beneath the secondary strata. From the river Vyrniew to Charnwood Forest the lower carboniferous strata are conspicuous by their absence, and therefore we may conclude that Professor Jukes' inference as to the existence of a barrier of land at this time in this direction is a true exposition of the facts.

Let us now carry our inquiry from Derbyshire northwards. In Yorkshire, under Ingleborough, the ancient beach composed of pebbles of the underlying rocks, divides the limestone from the Cambro-Silurian, and lies buried beneath

a great thickness of lower carboniferous rocks. Here it was depressed to a depth of at least six or seven thousand feet beneath the waters of the lower carboniferous sea, if we take the strata of Pendle Hill as a measure. In the Lake District the shingle beach appears in the same position encircling the Cumbrian mountains, near Grange and elsewhere, pointing to the existence of land at this time in that region.

If we trace the mountain limestone from Derbyshire northwards and eastwards into the districts of Durham and Northumberland, we find that the thick calcareous beds are split up by wedges of shales and sandstones, and by coal seams, or fossil vegetable accumulations formed on the land. Land, therefore, existed in that direction at that time. The depths of the sea being in Derbyshire—the sea shallowed; and throughout these districts, and into the south of Scotland, we can trace the position of the land not merely by the presence of shingle-beaches, but by the occurrence of coal seams interbedded with the limestones, as well as by the thinning out of the limestones. The shallows extended over the central valley of Scotland, and as far as the line of shingle-beaches on the southern flanks of the Highlands, which mark the shore-line. In the south of Scotland the sea covered the area of the Lammermuir Hills and the greater part of Kirkcudbright, and broke against two or more small islands, which are now represented by the higher silurian summits, such as White Combe and Broad Law.

The lower carboniferous sea covered by far the greater portion of Ireland. The same thinly-bedded lower carboniferous strata which we find in the central valley of Scotland—coal seams associated with limestones—occur in a small coal field of Ballycastle, Antrim, which lies buried under the dolerite of north-eastern Ireland, opposite to the Mull of Cantire. This indicates the nearness of the land to the

shore, which is marked by the shingle-beaches on the south-eastern flanks of the hills of Donegal, from Loch Foyle to Donegal Bay. From this point they run along the eastern side of the higher hills of Mayo and Galway to the bays of Clew and Galway. Still further to the south the shingle-beaches on the eastern side of Dingle Head and Kenmore mark the old shore-line of a land which was in the north-west, and of which the Highlands and the picturesque western hills of Ireland formed outlying parts on the sea-board. The Hills of Down and the Wicklow Mountains were islands, the latter, not improbably, being connected with Wales, across what is now the Irish Sea, while the higher ranges in the Isle of Man and the Highlands of Scotland stood over the sea between the island of Mayo and the island of Cumbria.

We have seen that the northern margin of the land barrier ranged eastwards in the direction of Charnwood Forest. The southern boundary is equally well defined. It passes across South Wales from the north of St. Davids in the direction of Tewkesbury and Northampton, where it is concealed by the secondary rocks. In the Forest of Dean and in South Wales we get about 1,200 feet of lower carboniferous rocks. Still further to the south the culm-measures of Devonshire are a shallow sea accumulation formed against a land which is composed of the same Archaian and Cambrian rocks as the region of St. Davids, and which, in my belief, extended over the area of the English Channel to the east to form the Channel Islands, and to the south to form the western hills of Brittany. From this land the carboniferous sea is proved to have extended over south-eastern England by the Yoredale rocks, struck in the boring at Harwich, and by the lower carboniferous strata of North France, Holland, and Belgium, and the valley of the Rhine.

Such as this is my conception of the conditions of land and sea during the deposit of the lower carboniferous rocks;

and I take it that when Derbyshire and this area in which we are was sunk in the depths of the carboniferous sea, the Highlands of Scotland and of the West of Ireland were dry land, and formed part of a continent, with outlying islands off its south-eastern coast-line.

We must now consider the upper carboniferous geography of our land. During the time of the accumulation of the Yoredales, which are so widely spread over the British area, the sea was becoming more and more shallow. There were considerable oscillations of level in the north, but the general drift of events was towards the sea becoming shallower, and the mud from the land encroaching on the shore end of the carboniferous limestone, and the sand banks following close on the mud banks. In this manner the petrified mud banks and sand banks, the Yoredales and millstone grit form one continuous set of rocks over the greater portion of the area which we have under consideration, and thicker in Lancashire, Derbyshire, and Yorkshire than anywhere else. While the land was encroaching on the area of the sea by the accumulation of these sediments, the terrestrial vegetation (Lepidodendra, Sigillariæ, Calamites, ferns, and conifers) was spreading from the old lower carboniferous land areas over the new upper carboniferous marsh lands, from the mountains of Wales, and from the other lower carboniferous islands, now uplands. These forests constituted in their decay, through many generations, the accumulation which now, compacted by pressure and subjected to earth heat, is familiar to us as a coal seam. Each coal seam represents a land surface, just as the sand banks and mud banks (sandstones and shales) above it point to submergence. The fact, too, that the coal seams which, in a given section, are parallel to each other, or nearly so, implies that the forests grew on horizontal tracts of land just as the associated sand banks and mud banks, with marine and fresh water shells, prove that these horizontal

tracts were near the sea level, or within the reach of the waters of a mighty river. We may also learn from the study of the isolated coal fields that this great horizontal tract of forest-clad alluvia occupied nearly the whole area of the British Isles in the upper carboniferous age, from the Scotch Highlands southward, the dead flat being broken only by the higher lands, the old islands of the lower carboniferous sea, which I have already described. It was, indeed, a delta of a mighty river analogous in every particular to that of the Mississippi—a delta in which from time to time the forest growths became depressed beneath the water until the whole thickness (7,200 feet in Lancashire) was accumulated of coal seams and associated sandstones and shales. After each depression the forest spread again over the bare expanse of sand and mud piled up in the depression. In this manner we can account for the fact that there is scarcely any, if any, change to be noted in the Flora during the great length of time implied by the great thickness of the carboniferous strata.

The enormous extent of that upper carboniferous delta implies a river of great magnitude, and a continent of corresponding size, to give the necessary drainage area. Such a continent is that north-western land, on the shores of which the lower carboniferous strata were laid down, and which I have named in my lectures before the Royal Institution in 1886, Archaia from the original *massif* being composed of Archaian rocks. To this northern and western land may be traced the pebbles and groups of pebbles found in the coal seams of Lancashire, such for example as the Trencherbone seam near Kearsley, and which have probably been brought down in flood time from the uplands in the roots of trees. They are without exception quartzites, and have probably been derived from a shingle beach of a sea that beat against Cambrian or Silurian rocks. The north-western

continent of Archaia occupied the North Atlantic area, stretching from the west coast of Ireland and the Highlands of Scotland to Greenland and the region of the St. Lawrence from the Cambrian age through all the succeeding periods down to the close of the miocene, and on its ever oscillating coast lines the British strata of the Primary and Secondary ages were accumulated. In the lower carboniferous times the various marine deposits were deposited on the eastern ever shifting shore-line of Archaia. In the upper, the mud banks, sand banks, and peaty morasses were accumulated in a great delta, flat and broken by uplands here and there, and extending from the Highlands southwards to Cornwall, and from Dingle Promontory on the west of Ireland far away eastward into the valley of the Rhine. At the close of the carboniferous period this vast tract of alluvia was broken up and folded; the Pennine chain was formed by one of its north and south folds; and on its sea-worn and battered edges the Permian rocks were deposited, both on the eastern and the western sides. It only remains for me to add that in this address I have entered upon the labours of Phillips, Godwin-Austen, Jukes, and Hull, and that I have dealt imperfectly and only in outline with a difficult and complicated question.

GEOLOGICAL SKETCHES AT PIETHORN AND DENSHAW.

By William Watts, F.G.S.

GLACIAL PHENOMENA.

The river deposits of Piethorn valley lie on the glacial drift which extends from the sea margin to an elevation of 850 feet above ordnance datum. Above this level the typical boulder clay does not exist in the valleys drained by the rivers Tame and Roach, which are carved in the westerly slopes of the Pennine Chain.

Few persons have had better opportunities than myself of observing the glacial phenomena in the districts named, and such is the result of my experience, which extends over a period of 20 years, at Swineshaw, Denshaw, and Piethorn valleys, in each of which extensive excavations have been made for waterworks purposes.

Piethorn brook pours its water into the river Beal at New Hey, which rises in the north of Oldham, and falls into the Roach at Rochdale. The drainage area of the Roach at the latter place is 21,920 acres, about one-half of which exists above the 600 ft. ordnance datum.

The highest hills in the Parish of Rochdale are :—

	Feet.
Robin Hood Beds	1553
Blackstone Edge Moor	1396
Knowl Hill	1378
Floxstone Edge Road	1377
Moorcock Rowly Moor	1324
Crow Knowl	1287
Brown Wardle	1314
Moorcock Inn Ogden Edge	1114
Windy Knowl	1275
Binns Higher Pasture	1200
Piethorn Hey	1175

On most of these hills flint implements of various kinds have been found, showing that primitive man must have roamed in the district over a wide area in early time.

The drift in the valley of the Roach is similar to the drift found in the valley of the Tame, with local variations.

The boulders consist mainly of Silurian grit, Eskdale granite, mountain limestone, flint, and a variety of fireformed rocks.

Several large boulders exceeding a ton weight were found in excavating for Ogden Embankment, and when the reser-

voir is low a porphyritic boulder fully 2½ tons is exposed on the northerly side of the valley, and a second one not much less lies at the same level below the waterman's house on the southerly side.

Most of the erratics found in Piethorn valley are rounded, and not a few are striated.

As a rule the large boulders are deeply embedded in the clay, and in the section opened out for the foundation of Ogden embankment, several redly coloured patches of contorted clay were exhibited, which appeared to have been subjected to lateral pressure.

Whether the drift of the character found skirting the southerly slopes, and filling the valleys of the Pennine Chain, be due to land ice or floating icebergs, is an open question, and much may be said in favour of both theories.

Isolated erratics, and perched boulders found at elevations exceeding 1000 feet ordnance datum, are witnesses in favour of land ice; also the fact of local grits being found in the clays reposing in the valleys is further evidence.

On the other hand, however, the clay, not being found higher than 850 feet, favours the theory of floating ice, and about the same level in Swineshaw, and Carr Brook valleys, loose rubble stones lie scattered about, as if they had been washed by the waters of a glacial ocean.

In most valleys in the Pennine chain the rivers, or brooks, have not cut their way more than a few feet into the boulder clay, and it would be interesting to know how the primitive conformation was formed, whether by the action of water acting mechanically on the sides, to widen and deepen them, or from other causes.

The lower reaches would assume a different shape compared with their present character prior to the last glacial period, which filled all the valleys with drift.

The valleys, and ancient river courses, were formed above

the sea level, and not below it; therefore we are led to imagine how much lower or how much higher the neighbouring hills were during the refrigeration of glacial time.

It may be assumed, however, that as the land slowly rose out of the water, the drift would be deposited in the valleys, and on the hill side; consequently the higher deposits would be the oldest; and those at the sea level the youngest, or most recent.

This evidence must be borne in mind when forming our conclusions as to which theory is the most feasible to account for the boulder clay nestling in the valleys 850 feet above the sea level.

I notice, however, that a greater number of granitic boulders are found at higher levels at Denshaw. A score at least were discovered at New Year's Bridge 900 feet above the sea, and six were found at Dowry 60 feet higher. No clay, however, was found with them, and in the higher valleys of the Tame they are more angular than the boulders discovered at Piethorn; but whether they are all drifted from one point of the compass I am not prepared to say.

On the easterly slopes of the Pennine Chain (in Todmorden valley) boulder clay has been found at an elevation exceeding 1,000 feet. I have not seen it, but I have seen moraine matter in a valley near Burnley, in great abundance, reposing on the hill side, which must have been left behind by a receding glacier.

Although many times searched for, I have not been able to discover glacial striations on the rock surfaces laid bare during our excavations; but it must be borne in mind how readily markings are obliterated in sandstone rock.

The subject is of great interest, and the Society must excuse me introducing it at such length.

Day after day my eye is accustomed to wander on these hilly slopes, and I see many places where former river courses exist. They are ill-defined, but silent witnesses of the wear and tear of mountain streams, and my mind feeds on their probable age, and I wonder whether the water parting of the anticlinal axis was physically different prior to the last glacial period, and whether more water was discharged from them into St. George's Channel than at present.

The rate of valley erosion must not be measured solely by the attacking forces we see in operation to-day, but we must enquire whether they have been greater or less in remote time. The erosive agencies are the same, but they may have been applied with greater force in former time.

The drainage area is unchanged except in conformation. The hills are being slowly weathered back, and becoming flatter on the top. In this way the rainfall is retained for a longer period, which fact must imperceptibly reduce the destroying effect of floods.

The valleys in the upper reaches are getting wider and deeper, and the unprotected surfaces are more liable to attack by atmospheric agencies than flat ground.

The erosive effect must lessen, as the hills are reduced in altitude.

Strewed on the higher slopes of Piethorn, and other places on the Pennine chain, may be observed large millstone grit blocks, mostly angular, but all more or less weathered.

The situation of many of them is most singular, and suggestive of forces other than meterological, having contributed to place them where they lie.

Accidental falling from parent beds, by the undermining action of the weather seems, to my mind, insufficient to account for the phenomenon, and we must look to other agencies than mere weathering for an explanation such as land ice, oceanic water, and surface upheaval.

The lateral rivulets on each side of Piethorn valley discharge into the main stream nearly at right angles, and at the head of the valley the brook divides into three streams.

The middle one drains 627 acres, the outer one to the left 480 acres, and the third stream on the right 80 acres; total, 1,187 acres.

Denshaw valley is differently subdivided. The carving is more irregular, owing to the hard character of the rock which immediately overlies the Kinder grits of the district. The drainage area down to New Year's Bridge, above the 945 feet contour, is 1,400 acres.

There is less detrital matter reposing on the hard rocks than in Piethorn, and of a coarser character.

The hills rise to an elevation of more than 1,500 feet, and the valleys are narrow and tortuous, with slopes tolerably steep, and mostly protected with a covering of scanty vegetation.

Trees have adorned them in the past at no distant date, as trunks and rootlets have been found embedded in the softer matrix spread over a wide area. Scores of stems and rootlets of the birch and hazel have been found in the clay at Readycondean, at an elevation of 1,268 feet above the sea level.

Hitherto I have dealt mainly with the physical features of the districts, and will now, for a short time, direct your

attention to the stratigraphy of the neighbourhood, which is very interesting.

There are few places in Lancashire where the Gannister beds can be examined to greater advantage than in the neighbourhood of Piethorn. All the lower coal seams, five in number, crop out in Helpit Edge, within a radius of half-a-mile, and it would repay the young student in geology to spend a short holiday in the district to look them up and study their bearings.

The diagram, which I have drawn to scale from Professor Hull's "Geological Survey of the Country around Oldham," shews their stratigraphical order. I have not checked them with my own level, but I believe them to be fairly accurate.

The beds yield many fossils to the collector, especially *Goniatites* and *Avicula-Pectens*, which may be found in the shales, and in a nodular form.

A good section of the Helpit Edge rock is seen in the roadway about 700 yards from New Hey station, up above which the 40 yards' mine exists; but I am not aware whether this coal seam is worked in the district or not at the present time.

The rock is flaggy and siliceous, and makes good setts for the road, for which it is extensively used. It forms the escarpment of Brushes Clough, Beasom Hill, and Helpit Edge, whence its name is derived.

Below the Helpit Edge rock lies the Woodhead Hill rock, which first appears in Wicken Hall Clough, and forms the floor of the Lower Yard mine, which may be seen near to a sycamore tree at the top end, before the stream is crossed by the turnpike road. The puddle trench of the Ogden embankment is tied into this rock, which is the last of the Gannister

series, and forms the crest of Ogden Edge, Bowstead Edge, High Moor, Saddleworth, and Ridge Hill, Stalybridge.

Lithologically there is not much difference between the Helpit Edge and Woodhead Hill rocks. They are flaggy and fissile, and neither forms an attractive building stone; but, on reaching High Moor, a change ensues, and a good grey stone is produced, lasting in colour, and capable of a good polish.

In a walk of a mile and a quarter all the Lower Coal Measure deposits from the 40 yards' mine to the Rough Rock, may be examined and studied. They appear in the streams, in hillside escarpments, and in road sections. To examine them *in situ* is to know them once and for a lifetime.

A beautiful section of the Mountain Mine, with its underseating, was exposed at the time of the Society's visit last summer.

I leave these interesting deposits with reluctance to enter on the Upper Millstone Grits, which first appear in a quarry opposite to the Piethorn embankment, and from which most of the ashlar for the waterworks in the valley has been got. It is a durable building stone, and works up very well; but it does not keep its colour owing to mica and iron stains entering into its composition in appreciable quantities.

Large concretionary nodules, of various shapes, are numerous in the beds, and are a source of loss to the quarryman, and worthless except for the commonest purposes, and require much time and labour to break them up. This drawback, however, is, to some extent, compensated for by the excellent quality of the rock surrounding them. How they originated I am not prepared to say, but their affinity for ferruginous matter was very great, as the iron in the surrounding matrix was attracted by them.

The second and third grits of the Millstone series lie mostly buried under the valley alluvium, and will have to be searched for in the brook courses to be seen. The second grits and shales were met with in driving Piethorn tunnel, which discharges the water from Denshaw into Hanging Lees reservoir, 884 feet above the sea level.

In executing this work, one or more seams of coal were met with, probably an expansion of the seam found at Mossley and Mottram. This seam has also been worked in a shaft on the roadside near to Martin Mill, Denshaw, but it proved a loss to the spirited proprietor, who was obliged to give it up after doing little besides finding coal which did not pay to work.

In passing over the outcropping beds of the millstones on the way to Denshaw, a good example of a local landslip, about 20 acres in extent, may be seen at a farm called Knowsly.

The house and buildings stand upon the crest of the slip, which has sloughed off the Woodhead Hill rock, and left a bold escarpment behind which gives a wild appearance to the scenery.

Since the buildings were put up, more than a hundred years ago, there does not appear to have been any movement of the ground. On a clear day the view from here is charming, the distant hills in the south-west being visible for at least thirty miles. The intervening valleys help to bring out the bold outlines of the hills all the better, and the morning mists and evening shadows lend enchantment to the scenery, on which the eye never tires to gaze.

We now leap over the second and third grits to Denshaw, where the latter, I believe, forms the base of New Year's Bridge embankment, also the quarry on the new road close by, sections of which are shown in the diagrams submitted for your inspection.

There is one structural feature worth notice in this rock, viz., the great number of shaley pot-holes, which I have endeavoured to show as naturally as possible, also a small fault on the south-westerly side of the valley, which I never failed to examine with interest during the time the work was in progress.

This rock forms the base of the valley as far as Readycondean, where it is lost under the hill on both sides.

At Rag Hole, about quarter of a mile from Dowry farm, the Kinder Scout Grits and the Yoredale shales appear. These grits form the base of the Saddleworth hills for miles, and give to that district its bold outlines and rugged appearance. You see them winding into Diggle, Greenfield and Chew valleys, bringing out the features of the parish, which contains 22,400 acres.

The bold headland of Boardhill Brow, or Alderman's Hill, with its renowned fairy holes, and pots and pans, are prominent land marks.

The fairy holes are clifts in the rock, formed by a landslip which occurred in the remote past, when the Greenfield brook was from fifty to sixty feet deeper than at present. The grits have slid on the shale forming the base of this promontory, and filled the narrow part of the valley with huge blocks, which subsequently had their interstices occupied with detrital matter brought down from the hills by the waters of the stream, which have shaped the present outlines of these upland valleys.

This geological information was brought to light by the excavations for the puddle trench of Yeoman Hey reservoir, recently constructed by the Joint Waterworks Committee of Ashton-under-Line and district. The trench had to be sunk to a depth of 80 feet before strata sufficiently impervious to

water under great pressure were arrived at, and in sinking mixed *debris* was met with till the ancient bed of the stream and solid strata were reached 80 feet deeper than the present level.

The Fairy Holes have not been formed, like caves and swallow holes in limestone deposits, by the action of water, as there is no drainage at the surface to supply the water requisite to erode cliffs several hundred feet long, and many yards wide. Indeed, there is no natural outlet for a free supply of water admitted at the surface, and to create friction and scouring there must be rapid forward flow of the water.

The Fairy Holes are outside the districts mentioned at the heading of this communication, but they can be seen from Broadhead Noddle. I introduce the subject that an expression of opinion may go forth from the Manchester Geological Society as to the cause of these chasms respecting which many opinions have been expressed by gentlemen of other scientific societies, with which I do not agree, believing that a solution to this debatable question must be looked for in the direction I have indicated.

The Kinder grits form a well-defined termination of the Millstone Grit series in this part of the country. They wind gloomily round all the valleys in Saddleworth, and top some of the neighbouring hills in Lancashire with a dark grey head, which is retreating backwards on the demands of time and atmospheric agencies.

All the minor hills and buttresses are rounded off and keep silent watch over the vales below. Smiling hedgerows give place to black bare walls, and the heather blooms where trees were wont to grow at no distant date. In course of time the roots are laid bare by the removal of the earthy covering, thus depriving the tree of its support, but more generally it

brings about its own destruction by preventing evaporation, the increased dampness at the roots being sufficient to kill the plant.

Trees can live only a natural life, and when their full growth is attained they begin to decline like animals.

Truly they are "earth born," but in growing they "weave the threads of doom," and cannot shift when the environment changes.

The discussion of the President's address and Mr. Watts' paper was postponed to a future meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XIX. SESSION 1886-7.

The ORDINARY MEETING of the Members was held on Tuesday, December 7th, 1886, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Professor W. BOYD DAWKINS, M.A., F.R.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary members of the Society, namely:—

Mr. HARRY SPEAKMAN, Bedford Collieries, Leigh.

Mr. ROBERT LAW, F.G.S., 11, Cromwell Terrace, Halifax.

The PRESIDENT said, before the business on the circular was proceeded with, he wished to make a brief communication to the meeting. There had been received from the British Association a circular calling the attention of the members of the Society to the committees which are collecting information on various subjects; and the two subjects which more particularly concerned them were the circulation of

underground waters, and underground temperature. The committee on underground waters had been at work for a good many years. If there were any members of the Society who cared to aid either of those committees, in the way of making observations, or otherwise, they would find the necessary papers in the hands of the Honorary Secretaries. The question of underground temperature was one, of course, which very nearly touched those who were interested in deep mines, and it might be that some members would desire to make observations which would be of use to the British Association.

NOTES ON OUTBURSTS OF GAS IN THE MINES AT THE CLIFTON, KERSLEY, AND NEWTOWN COLLIERIES.

By Mr. Herbert A. Woodward, M.E.

Having heard the opinion expressed by mining experts, that no such thing as outbursts of gas in mines ever take place, and having seen in the mining and other papers correspondence expressing doubts on the subject, must be my apology for bringing before you a statement of facts in connection therewith, which have come under my own personal observation at the above collieries.

I propose to put these observations before you in as concise and clear a form as possible, without note or comment.

I shall take the mines in the order of their position, commencing at the deepest mine, viz., the Cannel Mine, which, at the point where the outbursts occurred, lies at a depth of 400 yards from the surface, and at an average inclination of 16 degrees, or 1 in $3\frac{1}{3}$; the average line of

level being 55 degrees magnetic N.W. and S.E., and the rise and dip 35 degrees N.E. and S.W.

A large field of coal to the deep of the shafts was being opened out by engine planes and levels as shown on the plan, and there were no old workings where gas could be pent up, the nearest old workings being 500 yards to the rise.

OUTBURST No. 1.

Was in a rise place, 10 yards wide and 40 yards upbrow; with a pack wall in the centre, 4 yards wide; an air road down one side, 3 yards wide; and drawing road down the other, 3 yards wide; giving 160 square yards covered by pack wall, and 240 yards exposed in the drawing and airway.

The men working in the bay said :—We thought the bay was on the weight, as we heard a noise resembling weighting, and were alarmed; the props began to break (there were over 100 in the bay); suddenly gas began to fire in our lamps, and we went out with the return air about 50 yards, and then through doors into the intake level, and from there to the engine plane, and after reporting to the fireman in charge, went out of the pit.

On examination, it was found that nearly all the props in the bay were broken, and that the pack wall had sunk 3in. from the roof, and it had to be packed with straw to take the air to the face till such time as it could be plastered and made air-tight. The quantity of air passing was 4,275 cubic feet per minute, and the area of the air road 45 square feet, giving a velocity of 95 lineal feet per minute.

The much-abused Clanny Lamp was in use, but the men retired with the air current and not against it.

I personally examined this place some hours afterwards, but could not find a trace of gas.

The outburst came from the floor, as the spaces, not ocvered by the pack wall, were lifted up, and the pack wall had sunk.

The gas must have been holding up the floor and the pack wall as well under considerable pressure, and as soon as a sufficient area of floor had been exposed, the gas burst it up, and the weight of the pack wall forced it out at each side of the exposed floor like a pair of bellows.

The weight of the pack wall would be about $1\frac{1}{8}$ tons per square yard, built of dirt and inferior coal from the middle of the mine, and taking the area of the wall at 160 square yards, the weight would be at least 180 tons. Of course this is not a large pressure per square inch, amounting to a little over 2lbs. per square inch; from the dead weight of the pack alone the weight of the floor has to be taken into account as well, and is an unknown quantity.

Underlying this floor, at a depth of from 2 to 3 feet, is a seam of coal about 10in. thick, and we now sink holes as the narrow places are driven to let off the gas.

I may add that this bay was driven 120 yards afterwards, and that no further outburst took place.

Outburst No. 2.

In the same mine, 200 yards further to the east, some men were working in a level 4 yards wide; they said they heard a noise like thunder, and were retiring from the face towards the intake end of the brattice, when a portion of the roof was blown down, and gas fired in their lamps, they came out through it against the intake, and went out of the pit. Gas continued to come off strongly for 13 days, the air passing registered 5,700 feet per minute, and the area of airway 45 square feet, giving a velocity of over 126 feet per minute.

The Clanny Lamp in use.

Outburst No. 3.

After driving this level forward 38 yards, another outburst took place (in the night), similar to the one before described. The men were afraid, and remained at the face, as they thought the whole level was coming in. (The level was bratticed past the last cut through.) Gas fired in their lamps, which they put out, and then came out.

The roof was blown down almost like a staple pit, and gas came off for 7 days afterwards, and then ceased. The Clanny Lamp was in use, and the air current had a little less velocity than in the preceding case, *i.e.*, was reduced to 118 feet per minute.

The roof is a strong micaceous sand stone, mixed with bands of blue metal and iron stone nodules. The appearance of the two places brought down in the levels by the outburst is that of a pit, which was being sunk upwards. You may say this is a misnomer, but the sections on level and rise and dip will give a clearer idea to experts than any written description.

In the second case there were no open fissures visible; in the third there were three open fissures, ¼in. wide, running into the deep.

At a distance of 16 to 18 yards above this mine, there is a small seam of coal, 18in. thick, and I am of opinion that the gas came from the overlying mine.

Outburst in Doe Mine, No. 4.

This mine is, at the point shown on the plan, 270 yards from the surface, and the inclination and run of level the same as in the Cannel Mine.

An outburst of gas from this mine took place in, what is locally called, a dirt bay, on an east side level out of an

engine plane to the deep at 8 a.m., and ceased at 12 a.m. the same day. A strong smell of sulphuretted hydrogen came off with the gas, but no water.

The gas fired in the waggoners' lamps as they were coming out with their waggons from the far end working places 200 yards away from the dirt bay, and all the men on the level came out hurriedly, leaving their clothes, &c., behind them, and went up the shaft. (Some of them came next day and asked that their clothes and watches should be sent out, such was their terror.)

The other men in this district were at once sent out by the firemen.

The gas would fire in the return 400 yards from the point of outburst, but the air passed into the upcast by a dumb drift, and there was no occasion to fear an explosion from firing at the furnaces.

The quantity of air passing on this level was 8,050 cubic feet per minute; the average size being 54 feet area, which gives a velocity of 148 feet per minute.

Davy and Clanny Lamps were used, and it is probable that the men running out against the air current, and in a complete state of panic, doubled the velocity.

The dirt bay, from which this outburst took place, was driven to the deep of the level in 1876, and was filled solid with dirt, except a small space near the waggon road left for ventilation, and had a superficial area of 420 square yards—400 of which would be packed tight. In 1879 another bay was driven on the east or far end side of this bay, with the same length to the deep, and an area of 280 superficial yards, and then filled up solid, except a small space left open for ventilation near the waggon road pillar, and which the plan and section will explain more fully.

Probably, the getting of the second bay (in spite of packing) weakened the roof, and allowed it to bag, making a pocket in which gas gradually accumulated sufficient pressure to burst down the roof, and let off a body of gas at considerable pressure.

On examining this place next day, gas was coming off, but only to a very small extent, and it would fire in the lamp intermittently. Four days after, no gas was to be seen issuing, nor has any been seen since.

There were very small fissures in the roof from which the gas came, and there is no overlying seam at this colliery, except one at 54 yards above, which is not a fiery seam.

There were no old workings within hundreds of yards, except some to the rise at a distance of 300 yards. The whole of these workings were in solid coal, and, as a rule, light carburetted hydrogen does not go down hill except under compulsion.

I could add several instances of strong blowers of gas which have been met with in the Cannel Mine, and, after a period of seven years, are still giving off gas so strongly from the floor that it has to be piped directly into the return airway. Also from the rock roof of the Trencherbone Mine (the Wigan, 6 feet or 9 feet), these are not outbursts, but may lead to them unless care is exercised, and even then they may come in spite of all precautions.

When, in the same mine, you are subject to outbursts of gas from both roof and floor, it adds to the difficulties of working the mine. You may take precautions against outbursts from the roof by boring holes, but it may come from the floor, if you have not bored there.

History always repeats itself; it is always the unexpected which happens, and which is most difficult to guard against.

The PRESIDENT said they had all listened with the greatest interest to the admirable paper given them by Mr. Woodward, and he was sure the members would heartily join in presenting the thanks of the Society to him. The paper contained many points of genuine interest, and he knew there were many gentlemen in the room who would have something to say upon it.

Mr. WILD said it could not be too widely known that outbursts of gas did occur in mines, although, as Mr. Woodward told them at the outset, many people did not believe in them, but treated them as mere dislodgments from the goaf or some unventilated place. Of course they had blowers which had broken the shale down, and had continued to give off gas for some considerable time; but outbursts which made a rent in the floor or roof of a mine were more serious, and were more common than most people supposed. If he were to describe some outbursts which had occurred in his own experience he should but repeat the story so ably told by Mr. Woodward. He had known five instances in the mine in which he was concerned at Bardsley; and the memoranda he had preserved respecting these coincided precisely with a report made by Mr. Peter Higson in the year 1859. There was the same vitiation of the atmosphere, which became highly explosive, and in one instance remained so for 45 minutes, over a space of some 500 or 600 yards, the air travelling at the rate of about 1,000 feet per minute. The fireman in that case ascended by the upcast shaft, and the gas fired in his lamp. A subsequent examination of the mine showed that the roof had not fallen, but props were broken, and the floor had lifted. There was, however, no rent in the floor, only a puffing up. There was an outburst subsequently which rent the floor for about 16 yards; and 18 months afterwards, when they left the place, gas was still being given off, from

that rent. That outburst took place in the interval between two shifts, and it resulted in an explosion, causing one death. It was evident that the reliance still placed in the Davy lamp in some places might lead to serious mischief if the fact were not widely known that sudden outbursts of gas were liable to occur.

Mr. Cockson (Wigan) said that his own experience in the Wigan district fully coincided with that of Mr. Woodward and Mr. Wild. He had been underground at the time when outbursts had taken place, or shortly after, and was able to say that what he had seen were clearly and decidedly outbursts, and not simply blowers, of gas. Such outbursts had occurred in his experience in three different and distinct seams in the Wigan coal field. Those in which he had actually known them to occur were the Arley mine, the Haigh yard mine, and in the Pemberton 2 feet; so that, in his own limited experience, he could speak of five serious outbursts of gas in which either a distinct rent in the strata had taken place, or the floor had lifted, or the roof forced violently down, and a large quantity of gas had been given off. With regard to one of the outbursts in the Arley mine, which occurred at a colliery in Mr. Dickinson's district, the mine was 560 yards deep, and the outburst there occurred in a strait place in the solid coal. There were no workings near. The outburst took place from the floor; the strata near the face, and for some yards back from the face, were lifted about eighteen inches, and the rift in the floor, up against the coal side, was as clear as if it had been cut with a knife. At the same time water was given off, and sulphuretted hydrogen gas also was given off with the fire-damp for some days. Such outbursts having occurred in his own experience it was of course possible for them to occur elsewhere; and they must be taken as factors in their work, and factors which it was impossible for them to disregard.

Mr. STIRRUP asked with regard to the gas, which was given off in the manner described, whether there was any possibility of utilising it for heating or lighting purposes.

Mr. WOODWARD replied that, occasionally, blowers were used for lighting, but the lighting quality of the gas was so small, owing to the admixture of carbonic acid and other impurities, that it was of comparatively little service.

Mr. STIRRUP said he asked the question principally for the reason that Mr. Kinahan, an honorary member of the Society, had within the last few days sent him a paper—which would be read at a future meeting—on the gases given off in the coal measures. Mr. Kinahan drew attention to what was being done in America, and he put it as a question to coal owners in the Lancashire district, and other parts of England, whether it was not possible to utilise that gas in some manner.

Mr. DICKINSON said there were cases of the gas being utilised at the time it was given off: for instance at the Holme House Colliery, near Wigan, where they had all their workshops lighted for some time, until the pressure of gas got so weak it had to be discontinued. Its illuminating quality was inferior. At Ladyshore also they had the mouthing lighted up with gas from below until the feeder went off; and at the Outwood Colliery, in addition to lighting the mouthing, the gas was burned on the surface. At West Leigh also he had known it to be utilised; in fact it was not uncommon to utilise it, so long as the feeder lasted.

The PRESIDENT said that in the United States, as had been mentioned, great use had been made of the natural gas which was found stored up in fissures of the rocks. For instance, at Pittsburg, which till recently was overhung with smoke like Wigan, the atmosphere was now as bright

and clear as on any mountain top. The secret of this was, that instead of using coal in their furnaces and for household purposes, they now used the gas which was found stored in enormous quantities in the sandstones in the district. The result on Pittsburg was very curious. Apparently the people had so long been accustomed to black, that they were now painting the whole place white. But Pittsburg did not stand alone in the utilisation of natural gas for fuel. Only the previous day (*The London Guardian*, 1st Dec., 1886, p. 1813,) he read a very interesting account of the lighting of a place called Franklin, in Pennsylvania. It appeared that an Englishman, Mr. Speechley, who was of an inquiring turn of mind, set to work there boring; and he bored a hole six inches wide to a considerable depth till he struck a bed of sandstone, at a depth of 2,200 feet. This was apparently as highly charged with gas as any of the beds in the Pennsylvania oil district were charged with oil. The gas rushed up the bore-hole at an enormous pressure, driving the boring tool high into the air, the pressure at the surface was 600 lbs. to the square inch. The gas at the present time was being utilised, though the pressure, as might naturally be expected, had rapidly diminished. At the present time it was only about 250 lbs. to the square inch. He mentioned these cases because really they bore upon the general question of blowers and outbursts of gas. He fully believed that wherever there was space in the rocks for gas to accumulate, there it did accumulate. He was aware, however, that the gas met with in our coal mines was light carburetted hydrogen, with a good deal of water in it, and that consequently its illuminating power was very small. With regard to the general question of the accumulation of gas in fissures, he might mention an instance of another kind of gas being met with which was

really very remarkable. During the past summer he was at the bottom of the great Foxdale Mine, in the Isle of Man; it was a mine which yielded lead ore and other associated minerals in the solid granite. Down towards the bottom of the mine there was a place where enormous quantities of carbonic acid were given off. The gas was in such force that it made a hissing noise; they could hear it close to the face of the rock, and it was in such quantity that a special arrangement of pipes was required for drawing it off before it had time to mix with the atmosphere of the mine. He had listened with very great interest to the able paper by Mr. Woodward; and he could not, for one, understand how any reasonable man having anything to do with coal mining could deny the occurrence of outbursts of gas in mines.

Mr. DICKINSON said Mr. Woodward was quite right in saying that the occurrence of outbursts was denied by people who had not had experience of them. He (Mr. Dickinson) of his own knowledge knew of many, including one, which Mr. Woodward might have added to those he has given. The President had made a statement with regard to carbonic acid gas issuing from the rock in a lead mine, which was certainly most remarkable. He (Mr. Dickinson) never heard of a case of carbonic acid issuing with a fizzing noise; it was a most unusual circumstance.

The PRESIDENT: Quite so.

Mr. DICKINSON said that never in the course of his experience had he met with such a thing. Carbonic acid gas was given off silently, and he should like to be satisfied that what the President heard coming off was really carbonic acid gas. There was a case reported from one of the German mines where they said there was a sudden outburst of carbonic acid gas; but they had been firing some large charge of dynamite shortly before, and he could

never get his mind dispossessed of the belief that the appearances observed were due to the dynamite.

The PRESIDENT said, with regard to the particular case to which he alluded, it was a new working, and the manager (Captain Kitto) pointed it out to him. As to its being carbonic acid gas there could not be the shadow of a doubt, because it would put out the candles. He (the President) had never seen carbonic acid gas issuing from any mine before in that way.

Mr. DICKINSON: It is not unusual to see the gas issue out of old workings, like water, but it issued silently.

The PRESIDENT said he was at some pains to find out the exact position of the fissures out of which the gas was issuing. They were exactly on the face of the granite—just where the lead vein joined the face of the rock. It was a most puzzling thing how the carbonic acid got there; but there it was—there was no doubt about that.

Mr. DICKINSON said it sometimes happened when a mine was badly ventilated, that the bad state of the atmosphere was attributed to the sudden issue of carbonic acid gas, when there was no such thing taking place.

Mr. MCADOO said the subject was one upon which he might relate a little of his experience in Scotland. In one instance gas was given off in a sinking pit with a fizzing sound, and several workmen refused to go down because, as they said, the atmosphere was charged with carbonic acid, or, as they called it, "damp." The manager did not believe their story, and went down himself with two sinkers, and they had to be brought back. Gas was certainly fizzing out of the rock, but it was carbonic oxide, not carbonic acid, for the candles burned with an increased flame. He (the speaker) had several times seen carbonic

acid given off in mines. With regard to the paper he might say that he was one of those who for many years did not believe in sudden outbursts of explosive gas. In the district where he was brought up there was a good deal of fire-damp. This, no doubt, came from the floor of the mine, which, being soft, was not liable to sudden rifts. Four and a half years ago, during his connection with the Silkstone seam at the Nunnery Colliery, near Sheffield, an occurrence happened which convinced him of the reality of outbursts. There was a series of 14 "gates," each gate being 40 yards wide. He was in the No. 11 gate one morning—the fireman going his rounds before him—when he heard a report as of the firing of a shot. As a matter of fact, shots were not fired in that district and never had been. After hearing the report he could not get on; he found gas coming with the air, and at once took steps to fetch out the men. The air of the mine was foul for three days after. When an examination became possible the floor was found broken right along the face for at least 35 yards. He had ever since that believed in the possibility of sudden outbursts of gas.

Mr. Herbert Fletcher said they were all profoundly interested in this question of outbursts, and the instances given by Mr. Woodward were about the most startling that had been heard of in this part of the country. But he (Mr. Fletcher) understood that they all occurred in strait work. He would like to know if anyone could give an instance of an outburst of gas occurring in wide work in this district. In driving a narrow level in the Trencherbone mine 15 years ago, at a distance of about 150 yards below the old workings, a succession of blowers were met with—one of them of such volume, and making so much noise, that it was called an outburst. The men were working with naked lights at the time the warning came—and that warning was given by water preceding the escape of gas—yet, though the noise

made by the gas was likened by those, who heard it, to the blowing off of a steam boiler, no harm occurred to anyone, because the candles, and the furnace also, were immediately put out. There was no dumb drift by which the gas could escape. After that gas was found, small blowers continued to come at intervals of about 100 yards till the level was driven 400 yards further. The instances Mr. Woodward had given all occurred, he believed, in pillar work. He (Mr. Fletcher) supposed as pillar work, or strait work, came to be gradually abandoned they would hear less of such outbursts.

Mr. BURROWS said that gas was often found in broken or wide work, and it nearly always came from the roof. He argued that by the system of working wide work spaces were formed between the strata overhead for the lodgment of gas, which showed itself the first time a weight occurred. That this was so he thought had been pretty clearly shown by several explosions; and—speaking from his own experience—he should say that the same argument applied to the floor as to the roof, for, however good the ventilation, if they packed the waste full, it made no difference: there must be a sinking, and if the waste sank say two feet there must be a gap of that extent somewhere, which served as a reservoir for gas. It depended upon where the roof was going to break whether they could let off that gas safely or otherwise. He asked Mr. Woodward whether he had noticed water in connection with any of the outbursts he had described.

Mr. WOODWARD said there had been no water at all. The coal was perfectly dry. In one place the presence of sulphuretted hydrogen was detected, and he was surprised that water did not follow the outburst of gas.

Mr. BURROWS mentioned a circumstance which occurred in the Trencherbone mine. The waste was packed full with dirt, and three weeks ago it took its first weight. This was

sometime during the Friday night. It was found by the fireman next morning, when the gas was blowing off very freely, so that the place had to be stopped till the following Wednesday.

Mr. DICKINSON wished Mr. Woodward would tell the meeting what kind of lamp he was now using, after the experience he had related. The lamp he had been using was the Clanny, and it was clear he had had some fortunate escapes.

Mr. WOODWARD: The Marsaut is now the one in use at these collieries.

Mr. DICKINSON: It would be a pity to let your paper appear without so important an addition to it.

Mr. WOODWARD: We are using the Marsaut entirely, and have been, in these mines, for some years now.

Mr. DICKINSON observed that such escapes as Mr. Herbert Fletcher had just described—the candles being put out just at the moment of danger, and the furnace also being put out—were not to be trusted to. It was running the chances too fine. The danger was such as ought not to be incurred.

Mr. FLETCHER said he agreed with Mr. Dickinson in that observation. He only stated the case in order to show what danger had been encountered with impunity by men using candles which protected them from other dangers, which were not now under discussion. As the Marsaut lamp had been mentioned as safe in outbursts of gas, it was right he should tell the meeting that he had procured some of those lamps (and also some Mueseler lamps) of the very best pattern, locked with lead rivets, and provided with every means that ingenuity could contrive to prevent the so-called "reckless" collier from "tampering with his light." This lamp, he thought, was a rather flimsy thing to trust a man's

life to, so he said—"Let us put it to an easy test." He took it into the workshop, and exposed it to a jet of gas from an ordinary burner. The lamp, which was thought to be a perfect protection against explosions underground, immediately lit the gas when placed in contact with it. After that another lamp was tried, with precisely the same result. Those were the only two lamps tested out of two dozen procured. It was the Marsaut lamp with double gauze, iron shield, and lead rivet—a lamp which was said to give almost as good a light as a naked candle. So it would, no doubt, in one direction; but it cast large shadows below and above. Though it was an excellent lamp in some mines, and might often prevent accidents, yet, he thought, it was not one to be implicitly trusted, and, inasmuch as they still had explosions in mines, where the best possible lamps were used, he thought no one could say, that by the exclusive use of the safety lamp in all mines there would be an avoidance of explosions in future.

Mr. BURROWS asked Mr. Fletcher if he could give any instance, in England, where there had been an explosion with the Mueseler lamps.

Mr. FLETCHER said he was not acquainted with the kind of lamp used in every colliery in England in which there had been an explosion; but he was reminded that during the last few months there had been an explosion in Prussia, which caused the death of 45 persons. He had tried to ascertain what lamp was in use in that mine, but had been unable to do so. He should suppose, however, that it was the Mueseler. In a neighbouring colliery to theirs, not long since, a collier was burned, and left the mine without his Marsaut lamp. The man who went to the place to get it, afterwards, was laid up in consequence, as he (the man) himself stated, of having breathed the gas, into which he was obliged to go to find the missing lamp. Then, there was the explosion at

Normanton; of course no one knew, as yet, what was the cause of that explosion. He believed the lamp in use there was the bonneted Clanny. There was a fiery mine, where bore-holes had been made to admit of the escape of the gas, and where the non-escape of the gas was a source of uneasiness, the managers concluding, that, if it was not given off at the bore-holes, it must be accumulating in some cavity 12 or 15 feet below. He was told that the use of candles had been given up, and the best lamps resorted to, in that mine. The explosion occurred within six months after the change took place, and the inference was that blasting, which was safe for so long a period, when candles were being used, became unsafe, when they adopted lamps.

Mr. BURROWS thought that was rather bad logic. Unless Mr. Fletcher could show that what lighted at a Mueseler would not light at a candle his argument fell to the ground. If gas would light at a lamp, whether bad or good, it certainly would light at a candle. Mr. Burrows further argued that in a working place with good ventilation it was extremely doubtful whether more light would be got from candles than from well-trimmed Mueseler lamps.

Mr. WILD said he would not like it to go forth from that meeting that they had had no explosions at Normanton prior to the one which was so disastrous in October. Mr. Garforth told him himself that they had had lots of small ones, and that sometimes gas had been left burning in the goaf. That used to be the case when candles were used in the fiery seams near Oldham. At Normanton their difficulties arising from the presence of gas increased; they found that it did not drain off as formerly in small quantities; the thickness of the strata began to increase between the two seams, and they saw the danger of continuing the use of candles. Hence their determination to adopt the safety lamp. But whatever might have been the cause of the

recent explosion it would certainly not have been avoided by their continuing the use of candles.

Mr. DICKINSON said there was one other thing which should not go out without a word being said. There was such a thing as good and bad company, and there was such a thing as having good lamps not properly put together. He thought the cases of lighting up the workshop with the Marsaut lamp, which Mr. Fletcher had given them, would admit of some explanation. Mr. Fletcher, he did not doubt, could give them the explanation; or, if not, then he (Mr. Dickinson) could.

The PRESIDENT said this was a "burning question," which did not come within the scope of Mr. Woodward's paper. A question had been put to Mr. Fletcher, which, perhaps, he would kindly answer, as the subject was one which was of such general interest; but a discussion on the general question of lamps might be left to some other meeting.

Mr. FLETCHER said Mr. Burrows thought his logic was bad, but, pending the inquiry in the Normanton case, a fair inference, he thought, was, that practices were encouraged by the immunity from danger supposed to be given by the safety lamp, which otherwise would not be allowed.

Mr. BURROWS: No, no.

Mr. FLETCHER added, on the subject of the illuminating capacity of lamps, as compared with candles, that whilst the former cast a shadow on the roof which rendered an examination difficult; supposing the miner heard a crack, the light from a candle facilitated such an examination; in fact, the miner could see all that he wanted to see by simply turning his head. Gentlemen might be aware of the recommendation of Mr. Atkinson with regard to the use of lime-wash. It was pointed out that the great cause of

explosions, at all events in the Durham coal field, was dust rather than fire damp. Mr. Atkinson recommended the application of white-wash to the roofs of places and sides of the roadways; and, with the view of ascertaining the probable cost of carrying out that recommendation, provided it was embodied in a new Act of Parliament, he (Mr. Fletcher) had begun white-washing rather extensively. The men themselves had undertaken the white-washing of the roofs of their places, and day-waymen were employed upon the roadways, tunnels, and jig-brows. Mr. Dickinson asked if he could not give some explanation of the manner in which the Marsaut lamps were lighted when placed in contact with a jet of gas. It was only fair to say that it was done by screwing the lamp up as little as possible, just so that it would lock; but being a new lamp, it was less likely to allow itself to be slackly screwed up than it would be after having been some time in use. With every day's use the lamp approached such a condition by the wearing of the screw and the lock, and so was rendered less and less safe. To trust to it would be "trusting to a broken reed."

Mr. DICKINSON: You have not explained the other matter—where there was an explosion.

Mr. FLETCHER said that was at a neighbouring colliery. He was told in that case there was only one gauze in each lamp. The men complained of the bad light given by the lamps, which they had had in use for some time, and they found great advantage from taking off the cover and using only one gauze. The lamp, he was told—he of course only gave it as hearsay—in that condition passed the flame. Whether it was a case of not being screwed up tight or not he was not in a position to say.

The PRESIDENT said he had listened with great interest to the discussion. It seemed to him, as a layman, that they

could hardly compare the carefully conducted experiments which had been made with the different kinds of lamps with the somewhat sporadic experience to which they had listened. He thought it ought not to go forth from that meeting that the Marsaut lamp was to be placed in the same dangerous category as the Davy.

Mr. DICKINSON: I think Mr. Fletcher's explanation quite removes the difficulty he would otherwise have left the meeting in.

THE QUESTION OF THE PRE-ATLANTIC LAND.

BY MR. R. T. BURNETT, F.G.S.

When we look at a geological map of the British Isles, we are struck with the pronounced way in which the different colours on the map are arranged.

Upon looking to the north, north-west, and west, we observe large areas of one or two colours only; whilst along the centre of the map, stretching from N.E. by the river Tyne down to the district of Lyme Regis in the south, there appear, more or less irregular, bands of colours roughly curving outside each other with their outer bendings to the south-east.

Consult an index to these colours, and we at once find that they indicate the stratigraphical arrangement of the different rock formations.

This index further shows us that these curving bands of colour represent rocks comparatively new when compared with the large patches to the north and north-west.

Read over the index, and you will find that the rock formations are arranged in tabular form, the oldest being at

the bottom, and the newest, or most recent, at the top of the table. Thus from the Pre-Cambrian and Cambrian up to the recent.

Turn now to the map. Place your ruler directly across from *Harlech to London*, running N.W. and S.E., or from Cape Wrath to Beechey Head, running N.N.W. to S.S.E., and you will then find that you pass over most of the formations rising from the oldest to the newest. Reflecting upon these colours and their index, together with the position of the rocks they indicate, we are aware that the oldest rocks appear to cluster to the N.W. and the newer rocks to the S.E.

Indeed, this will apply to the existing geology of the centre of England, the rocks of which occupy a truly physical and geological centre, being bounded by older rocks on the west and newer ones on the east.

Seeing that the older rocks known as Cambrian, Silurian, Devonian, and Carboniferous, occupy the main position to the N. and W. of the map, we naturally arrive at the conclusion that they form the nucleus or core around which have been built the more recent formations.

If we are correct in this, and in the reading of our map and index, and also in the identification of the rock masses, we are driven to affirm that Britain has undergone a process of building up towards the S.E., and that such building up took place from N.E. or N.W.

Admitted, then, that all the present exposed and existing *old* rock masses represent such nucleus out of and around which the present Britain has been constructed, we are further compelled to admit that those same ancient masses must themselves have been derived from pre-existing lands, and we ask, where was this pre-existing land?

In this question we enter upon very debatable ground, and we have the opinions of two eminent scientific leaders to consider, namely, Sir W. Dawson, of Montreal; and Professor Hull, of Ireland.

Dr. Dawson in his presidential address at the recent meeting of the British Association at Birmingham, when dealing with the theories of the original cooling of the earth said we were invited by a general glance at the surface of the earth to ask, respecting the Atlantic, "what has deter- "mined its position and form?" and "what changes has it "experienced in the lapse of geological time?"

To enquire into the cause of the Atlantic depression Dr. Dawson says "we must go back to a time when the areas "occupied by the Atlantic and its bounding coasts were "parts of a shoreless sea, when the earliest gneisses or "stratified granites of the Laurentian age were being laid "down in vastly extended beds." Taking all stated theories, quoted by him, into consideration we might well believe "that the cooling crust has hardened in successive "layers from without inward—that at the same time fissures "were locally discharging igneous matter to the surface, "that matter held in suspension in the ocean and matter "held in solution by heated waters rising from beneath the "outer crust were mingling their material in the deposits "of the primitive ocean," and that "the combination of all "these agencies may safely be evoked *as the causes of the "pre-Atlantic deposits.*"

Dr. Dawson further says:—"Let us suppose, then, the "floor of the old ocean covered with a flat pavement of "gneiss, or of that material which is now gneiss, *how* and "*when* did this original bed become converted into sea and "land?" In answering this question, he admits that "here we have some things certain, others *most* debatable."

He says, which we may admit, "That the cooling mass, in "sending out the softened rocky material, soon became too "small for its shell is apparent." "But," he asks, "where "would the collapse, crushing and wrinkling inevitable from this cause begin?" Where they did begin is indicated by the lines of mountain chains which traverse the Laurentian districts, but the *reason why* is less apparent. In attempting to give reasons for this collapse, crushing and wrinkling, Dr. Dawson gives: (1) "The more or less un- "equal cooling, hardening and conductive power of the "outer crust. (2) The driftage unequally of water borne "detritus to the S.W. by the bottom current of the sea. "(3) The greater cooling and hardening of the crust *in* "*the polar regions*, and the tendency to collapse of the "equatorial protuberance from the slackening of the earth's "rotation, and (4) the internal tides of the earth's substance "at the times of solstice would exert an oblique pulling "force on the crust which might tend to crack it along "diagonal lines." "From which ever of these causes, or "the combination of the whole," continues Dr. Dawson, "we know that within Laurentian time folded portions of "the earth's crust, began to rise above the general surface "in broad belts, running from N.E. to S.W., and from "N.W. to S.E., where the older mountains of Eastern "America and Western Europe now stand, and that the "subsidence of the ocean allowed by this crumpling of the "crust permitted other areas on both sides of what is now the "Atlantic, to form limited table land. The distribution of "this ancient land is indicated by the long lines of old "Laurentian rock, extending from the Labrador coast and "the north shore of the St. Lawrence, and along the eastern "slopes of the Appalachians in America, and the like rocks "of the Hebrides, the Western Highlands, and the Scandi- "navian mountains."

After stating that "the Arctic lands were subjected in "addition" to the ordinary atmospheric agencies "to the "powerful mechanical force of frost and thaw," and that "the lines of folding on both sides of the Atlantic to carry "south-westward, and pile up in marginal banks of great "thickness the debris produced from the rapid waste of the "land *already existing in the Arctic regions*," and further, that "in the later Eozoic and early Palæozoic times, which "succeeded the *first foldings* of the *oldest Laurentians*, great "ridges were thrown up along the edges, of which were "beds of limestone, and on their summits and sides thick "masses of ejected igneous rock." Further, *that "in the "bed of the Central Atlantic there are no such accumulations*," but that "it (the Atlantic) must have been a flat or slightly "ridged plate of the ancient gneiss, hard and resisting, "though perhaps with a few cracks through which igneous "matter welled up, as in Iceland and the Azores in more "modern times."

Dr. Dawson makes this very pertinent comment, viz.: "It "may be said that all this supposes a permanent continuance "of the ocean basins, whereas many geologists postulate "*a Mid-Atlantic continent to give the thick masses of detritus "found in the older formations, both in Eastern America and "Western Europe, and which thin off in proceeding into the "interior of both continents.*"

This really is the point at issue between the hypothesis of Dr. Dawson on the one hand, and that of Professor Hull on the other.

We cannot go into further detail of Dr. Dawson's views, but simply add that he says he "prefers, with Hall, to "consider these belts of sediment as in the main the *deposits "of northern currents and derived from Arctic land*, and that, "like the great banks of the American coast at the present

" day, which are being built up by the present Arctic " current, they had little to do with any direct drainage " from the adjacent shore."

With regard to the foregoing extract, Professor Hull says that in reading this particular passage, it occurred to him that Sir William Dawson must "have felt he had a very " questionable case when he attempted to support it by such " an hypothesis. To liken the *great sheets of sediment which* " *spread themselves sometimes over half the North American* " *continent*, south of the great lakes, *to the banks heaped up* " *along the Atlantic coast*, is a point of analogy in which, " probably, he will find few to concur. The Palæozoic " sediments are certainly not banks, but *sheets*, originally " spread over the sea-bed, and distributed according to " certain recognised laws of increase and decrease of " thickness."

This objection of Professor Hull's seems a fatal one to Dr. Dawson's hypothesis, because we have no evidence of such widely-spread deposits being in process of formation at the present day as *marginal* deposits.

Professor Hull further presses this objection when he says: "How can we suppose the existence of a northern " current bringing sediment from the Arctic regions and " spreading it over Eastern America unless there was at the " same time a coast line to guide the current in taking a " southerly direction; and if such a coast line existed must " it not have lain along the eastern American shore, because " the American continent itself was then submerged? If " America and the Atlantic, south of the Arctic regions, " were both oceanic in Palæozoic times then the current " would not have been southerly, but westerly or easterly, " not flowing from north to south; therefore this explana- " tion for the distribution of the Palæozoic strata cannot, I " venture to say, bear the test of examination."

Professor Hull says: "The question between the Presi-
" dent and myself is mainly this: *Did the sedimentary strata*
" *of the Palæozoic period of North America come from lands*
" *lying around the Arctic circle or from others occupying the*
" *position of the North Atlantic?* American geologists have
" a favourite theory that the Arctic regions have been the
" originating lands; but I venture to repeat that if it be
" allowed as a general principle that the originating lands
" lay in the direction towards which the sediments thicken,
" and opposite to that in which the limestones are most
" developed, the conclusion is inevitable that the Atlantic
" was in the *main* a land surface in Palæozoic times. All
" the Palæozoic formations of North America point to this
" conclusion, as I have on former occasions attempted to
" show, and this regardless of the question whether or not
" there was also land along the Arctic circle. Throughout the
" Silurian, Devonian, and Carboniferous epochs *marine lime-*
" *stones were in course of formation, mainly over the regions west*
" *of the Mississippi,* and *sediments mainly east* of that line, and
" chiefly in the Appalachian region. The general direction
" of the swelling out of the sediment is (if I mistake not)
" rather *south of east* than north of east. On the whole, and
" as a general result, the centre from which the sediments
" appear to have been chiefly distributed seems to have lain
" around the point intersected by the *parallel 30° N. lat. and*
" *the meridian of 60° W. long.;* except in the Carboniferous
" period, when the originating lands appear to have been in
" the region of the first Atlantic cable, between Newfound-
" land and the British Isles, and which lands were probably
" continuous with those of the Arctic continent."

Professor Hull, in conclusion, says with reference to the Archœan rocks: "I am much disposed to concur in the view
" of Sir W. Dawson that the fundamental gneissose beds
" may have had a different origin from the metamorphic

" strata of succeeding periods, and that they may not have " been originally sediments. This observation does not, " however, apply to the schists, limestones, and quartzites " which succeed them and which sometimes include beds " of gneiss as in Scandinavia. From this point of view " the birthday of the Atlantic continent may not have " dated further back than the commencement of the " Palæozoic age—represented in Britain by the Cambrian " and in America by the Potsdam sandstone. As a con- " tinent it remains till the close of that age. To what " extent it survived the terrestrial movements which closed " that epoch I am not prepared to say."

The foregoing extracts give a generalised idea of the exact position of the question debated by these two leaders of thought in physical geology.

There is one other authority we may allude to with a great degree of confidence. I refer to Professor Bonney, who in his presidential address to section C of the British Association says: "It may be convenient to " call your attention to granitoid rocks (many of which " may be of igneous origin but are of very ancient date), " gneisses and crystalline schists. . . . . The former " constitute a large part of the north-western and central " highlands of Scotland and of the islands off its west " coast."

Referring to the Archæan period, which more particularly bears upon the question in dispute between Dr. Dawson and Professor Hull, Professor Bonney says: "At the commence- " ment of the Cambrian period great masses of Archæan " rock, granitic gneisses and schists, must have existed not " only on the western side of Britain but also *over a con-* " *siderable tract of land now covered by the sea.* Detritus from " this continent became an important constituent in the

" Cambrian rocks, and in many cases, as at St. Davids, in " Anglesey, Carnarvonshire, &c., the *shore line* must have " been very near at hand. . . . . It is, I think, at present " hardly safe to attempt to trace the exact land boundaries " of the *Cambrian* ocean, but the *enormous masses* of *Archæan* " material which are entombed in the earlier palæozoic " strata of Wales and of north-west Scotland can, I think, " only be explained by the proximity of a *great continental* " *land*—an extension of the present Scandinavian peninsula— " which not improbably had a general slope towards the " S.E., the main watershed of which may have lain *some* " *distance to the west of the Outer Hebrides.*"

Thus we see that we have these three great authorities agreeing in the belief that the material for the commencement of the building of the foundation rocks of the British Isles was derived in the first instance from land existing to the west and north-west of what is now the farthest existing extension of our land in these directions.

Viewing the question as onlookers, watching the combat between the principle authorities, we cannot help seeing that each of them asserts most reasonable views, and, to a certain extent, advances towards the other very closely.

Dr. Dawson certainly does not yield the permanency of the Atlantic basin, but he steps far towards Professor Hull when he admits that the Arctic continent may have extended more to the south than it now does.

Professor Hull advances towards Dr. Dawson when he draws upon the Arctic continent, or upon land to the N.W. for material forming a Laurentian and Archaic land.

May it not be that both authorities are right up to a limited point? Dr. Dawson right in asserting that the

deepest parts of the Atlantic have never formed dry land at any time; the condition of the gneissic floor as being made up of non-subærial rocks supporting his view. This might be safely granted to the Atlantic south of an imaginary line drawn across from Britain to Newfoundland, and advancing towards the Equator from that line, so stretching E. and W., we should have the Atlantic basin deepening towards the south. Along that line we have the plateau proved by soundings.

May we not meet the hypothesis of both those gentlemen by another hypothesis, namely, that the Arctic continent existed as a high pre-Laurentian land, and extended so far south as the line in question, furnishing sediment to the pre-Eastern American seas on the west, and to the pre-Western European seas on the east.

The denudation of this high pre-Atlantic land would in all probability be sufficient for this, and the subsequent great depression of such of the land as might have been spared from denudation would be sufficient to assist in great part in the upheaval of long ridges forming the Laurentian land on the American and European continents.

Granting Dr. Dawson's hypothesis as to the original shrinkage of the crust forming the initial depression of the Atlantic basin, and its subsequent deepening towards the Equator, we have only to assume that the Atlantic depression did not extend north beyond the imaginary line drawn from Britain to Newfoundland, and we should then have the crust from that line up to the far north becoming solid, and forming a pre-Atlantic land. Yet not *wholly* a pre-Atlantic land, because *south* of our line the Atlantic would always have been the Atlantic, the subsequent extension of it north beyond the line in question up to the Point

Farewell, in Greenland, being permitted by the subsequent denudation, and deep submergence of the land up to that point.

In short, that the existing southern extension of Greenland is but the remaining projection of a land that once stretched much further south, and formed one of the original staying ribs of the cooling crust.

While much stress has very reasonably been put upon the configuration of the land of the globe broadening to the north, and attenuating towards the south, as shown by the European, African, and American continents, together with their intervening deep seas of the Atlantic, Pacific, and Indian Oceans, as all pointing most truly to the original lines of the earth's shrinkage, and also as to these three southernly projections of forming the three original ribs, might there not have been a fourth rib, which has been worn down and shortened, covered over by much newer deposits of rocks, and subsequently by snow and ice? That fourth rib being Greenland.

If, as is asserted, the first cooling and hardening of the earth's crust took place at the Poles, and that the last part to harden would be at the Equator, then the land grew out from the north. If this be so, then why should it not have originally projected out *four*, or more, binding ribs as well as three, or why should not the first hardening and subsequent forming of dry land commence at what is now Greenland and project far to the south, to be subsequently depressed into an ocean abyss, the future lifting and building up of the nucleus of the existing continents of Europe and of America being at its expense.

That this hypothesis is reasonable, I submit.

This being granted, we may well concede Professor Hull's hypothesis of a pre-Atlantic land to the W. and N.W.

If we concede this, we then have a very ancient land which furnished material for the Laurentian rocks, and those, in turn, for the subsequent building up of the British Isles through all the various succeeding epochs.

Discussion upon this paper was postponed.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XIX. SESSION 1886-7.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, the 7th January, 1877, in the Mining School, Wigan.

Mr. W. S. BARRETT in the Chair.

NEW MEMBERS.

The following gentlemen were duly proposed and unanimously elected Ordinary Members of the Society:—

Mr. GEORGE BOOLE, Rainford Colliery, near St. Helens.

Mr. CHRISTOPHER MEADOWS, Manager of the Earl of Bradford's Collieries, Bolton.

Mr. J. MCKINLESS, 1, Gore Street, Greenheys, Manchester.

Mr. ANDREW JACKSON, Manager, Collins Green and Bold Collieries, Newton-le-Willows.

From the 24th to the 30th October, a barometric fall of 14 millimètres took place; twenty-four hours before the atmospheric pressure attained its minimum the explosion occurred.

ADDENDUM.

Whilst this second edition was being printed there appeared in the periodical "Zeitschrift für das Berg-Hütten und Salinenwesen im Preussischen Staate," XXXIV. Vol., I. Part, pp. 72-90, the Report of experiments respecting the influence of changing atmospheric pressure on the production of fire-damp, by order of the Prussian Commission on Fire-damp, reported by Herrn C. Hilt, in Aix-la-Chapelle.

According to this report, the experiments at Aix-la-Chapelle serve as a splendid testimony to the results obtained in Karwin.

The Archducal Financial Direction in Teschen therefore considers that the question which formed the subject of the Karwin experiments to have been solved, and will henceforth abstain from further publications in this matter.

DUST IN MINES.

By Mr. M. MERCIER.

In taking the above subject for a short paper to read before this Society, I wish to state that my reason for doing so is—not to communicate any fresh experiments, but to give a condensed account of the production of coal dust in mines, with the means proposed for preventing its generation, together with the various proposals for rendering its presence in a mine harmless. The primary object of this paper being

to open the field for discussion on a subject that requires the careful consideration of all colliery managers, as there is great probability of coal dust being the subject of legislation during the next session of Parliament. It therefore behoves all colliery managers to consider the means at their disposal for dealing with and counteracting its evil properties. It may be taken for granted that all or nearly all colliery managers and mining authorities are now agreed that coal dust does, and has in the past played an important part in augmenting the intensity and disastrous effects of many of the explosions in mines; whilst a great many authorities are of opinion that coal dust can by itself under certain favourable conditions cause an explosion similar or even more severe in character and effect, to that caused by fire-damp alone—a proof of which may be cited in the late sad calamity at the Altofts Colliery. Evidence of the former is amply furnished by the explosion at Seaham, Dinas, Trimden Grange, &c. To go into the proof of the theories is unnecessary, as it is dealt with extensively in the report of the Royal Commission on Accidents in Mines, and also very fully and concisely in the valuable work on "Explosions in Coal Mines," lately added to the literature of the mining world by Messrs. W. N. and J. B. Atkinson, Her Majesty's Inspectors of Mines, and which should be read by all who are interested in so important a subject. Now, in the first place must be considered the causes responsible for the large amount of this dangerous matter in most dry mines, which will probably be accounted for severally or collectively by the following:—1. The working and getting of the coal at the face. 2. Decrepitation of the pillars and coal scattered in the roadways. 3. Leakage from tubs and boxes. The remedies for these evils may be found in the following:—1st. Mode of working, in which there is not much room for improvement; the long-

wall system being considered much superior to pillar and stall, as it does not leave any pillars to crush and decrepitate, which when being removed produce a large amount of fine dust. 2nd. In the mode of haulage and form of tubs there is probably the most room for improvement, as the systems in use in many collieries are very prolific in the generation of fine dust. The worst of which seems (*a*) the use of boxes made of green timber, which after a few weeks use in a dry mine shrink and leave a wide space between the boards, through which the dust is continually falling; (*b*) the form of boxes in use in some of the South Wales collieries, which have the sides constructed of a lattice work of iron. The remedies for these are—(*a*) The use of dried and well-seasoned timber in the construction of wooden boxes, which should in all cases have grooved or covered joints. (*b*) The use of sheet iron boxes, fitted with wooden or india-rubber buffers to reduce the shock caused by the boxes jamming against each other. (*c*) The systems of haulage at high speeds, are probably the greatest producers of dust, and wherever possible should be superseded by some form of haulage that can be carried out at speeds of two to three miles an hour, such as endless rope or chain with a double line of rails. After having as far as possible remedied the causes of dust generation (which remedies can be only partially successful), there must next be considered the means available for dealing with dust in mines. The first consideration must be its removal from the workings; and the next how to render its properties of danger harmless. With reference to the former, the removal of the dust entirely is not practicable, for to be done properly would require an army of scavengers being kept constantly at work, and even then the finest and most dangerous particles would still remain; again, unless water is copiously applied during its

removal large clouds of fine dust will be constantly passing with the currents of air to the danger of the mine, and will be again deposited on the roof, sides, and floor of the roadways. With reference to the latter consideration, viz., how to render the dust harmless, there have been several methods proposed. 1. It has been proposed to raise the temperature of the intake air to the natural heat of the mine; it being claimed that all air entering the mine at a low temperature is gradually raised, in doing which most of the moisture is evaporated from the dust. This antidote (which would only prove partially effective) is most impracticable, at it would be very costly to artificially heat the air some 20 to 40 degrees, and as deep mines are at present much too hot for comfortable working, if the temperature of the mine be thus increased, as it would by the suggested method, it would probably necessitate the paying of extra wages in the getting of the coal. The heated air would probably affect the roof and sides of the mine, and also decrease the quantity and efficiency of the ventilation, so making the "cure worse than the disease." 2. Strewing the workings with common salt or brine has been proposed, and is used to some extent to keep the dust in a moist condition. It gives good results if used on the following basis: One pound of salt per square yard of area, applied once a week for first month, and once a month afterwards. Its use has the following disadvantages: Salt is expensive, costing about 9s. per ton (though if used extensively it could probably be obtained at a cheaper rate). The cost of labour in spreading the salt will be heavy, and additional matter will have to be removed, this again adding to the already heavy cost of working mines. 3. The turning of exhaust steam into the air courses has been proposed, but anyone who has had to do with steam engines in a mine, knows the havoc it works with a roof composed of shale,

therefore there is little probability of this method being used to any extent. 4. The best and most practical method is the watering of the roads by (*a*) water carts or (*b*) the laying of pipes in the haulage roads and main air courses; both of these methods have their advantages and disadvantages. These require very careful consideration, as it will be in these directions that the solution of the problem must be expected. (*a*) The watering of main intakes and returns by water carts, of which there were several varieties, viz., ordinary water carts with holes in the bottom, carts constructed on similar lines to those used in street watering, with a pipe at the back to diffuse the water by its flowing through small apertures in the pipe. A very ingenious cart was constructed by Messrs. Smethurst for use in their mines at the Garswood Hall Colliery. It consisted of an ordinary water barrel mounted on tram wheels. At one end was fixed a hollow circular rose perforated with small holes round its circumference, and connected by gearing to a toothed wheel on the axle of the tram wheels. The water was delivered into the centre of the rose or disc, which, revolving very rapidly when the tub was in motion, scattered the water by centrifugal force against the roof, sides, and floor of the roadways. The disadvantages of this system are—1st. The cost of conveying the cart about the mine, which will also interfere with the ordinary coal traffic. 2nd. The cost of keeping a road constantly laid in the return air courses. 3rd. The water falling in one place only when the carts are stationary, will have an injurious effect on the floor in that particular spot; this, however, can be remedied by so arranging the cart that it shall automatically close the outlet when the cart is not in motion. The second system consists of the laying of water pipes along the sides of the main roads and air courses; this appears the most feasible, if properly arranged to conduct water from the

surface, or any convenient level in the shaft. The pipes being provided at suitable intervals with collections of small holes or apertures to diffuse the water, in the form of five sprays into the roads. The distance apart of these sprays would have to be determined by practice, and should hardly need to be less than 10 to 20 yards. This system if properly carried out with a good head of water, possesses the following advantages:—1. Is a very efficient method, as the water can be turned on when the mine is not working so as to cause no inconvenience to the men employed. 2. Does not require the keeping of a permanent road in the return airways. 3. After the first cost of pipes and fixing would not require any heavy expense to keep in working order. 4. Would prove of great service in case of fire in the mine. 5. Can be connected with the working face and drawing roads by flexible tubing. 6. Will not injure the health of the men as the atmosphere will not be saturated with moisture in suspension during the time the men are at work. 7. Can be so regulated that only the proper amount of water shall fall on the roadways to damp the dust, as with a soft flood the water in excess will cause the warrant to heave. Its disadvantages are:—1. First cost of pipes and fixing, which will be heavy. 2. Danger of the small apertures becoming clogged by dust and dirt. 3. Danger of the pipes being broken by falls of roof and sides, and the lifting of the floor. These can be somewhat guarded against by having the pipes slung from the timbers, and providing expansion joints and stop-cocks, so that the water can be turned off at any particular point or branch during repairs. 4. The necessity of having clean water free from all matter in suspension and accompanied by a good pressure, this again being of itself a counter disadvantage, as it necessitates the use of stronger pipes. 5. The necessity of having suitable settling tanks

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almost managers make remarks in that direction. They said they did not like to trust entirely to glass. The reason for this misgiving was that the lamp now used depends on glass alone, and because it is made up of so many parts that it is difficult to fit and liable to be passed when it is not in a safe condition: also because the gauze was so hidden by screens that it was quite impossible to examine the lamp. Indeed, one had to take it for granted that there was a gauze in it at all. In selecting a lamp for a colliery, one must take all the circumstances into consideration; but we seemed lately to have taken only one circumstance into consideration, and that was that the lamp should withstand a high velocity of explosive atmosphere. This doubtless was a most important consideration, but he thought there were other things that should be taken into account. In all his experience he had only once seen an explosive current travelling quickly, and almost daily he saw accumulations of gas in quiet parts of the mine. That being so, they wanted a lamp that would be safe in quiet parts of the mine more than one that would be safe in an explosive current travelling rapidly, because the lamp had to be taken to quiet parts where there might be gas every day, whereas the other circumstance—a high velocity of explosive air—might never occur in the history of the colliery. He thought, also, that the contingency of a glass lamp getting broken in the neighbourhood of quiet gas was much nearer than the contingency of a gauze lamp passing the gas through meeting with a current travelling at a high speed. The lamp he now submitted had been contrived with the object of doing away with the dependence upon glass. Although the glass might be broken in this lamp, they still had the gauze to protect them from firing the gas. Another recommendation, to his mind, was the simplicity of the lamp's construction.

Instead of consisting of 12 or 14 different pieces, there were only five, and the lamp could be examined at any time of the day, there being nothing hidden about it. His experience taught him that accidents frequently happened to lamps in mines, and where the protection of the light was simply glass there was great risk of an explosion. In the case of the lamp under review, if the glass shield got broken, there was the gauze to protect the miner from destruction. He did not want it to be understood that in his view a lamp with the gauze entirely unprotected would be a good thing, or that the old Davy should be continued. He thought that the days of the Davy had gone past, that is, in its unprotected state, but his view was that it will be a very bad thing if they discard the gauze. It seemed to him that the gauze had really been the great safety in the past, and he thought that it was likely to be so in the future. The lamp before the meeting was merely a step in the direction that he had pointed out. He believed that if they could get a lamp without discarding the gauze that would give sufficient light, that was the lamp they wanted. And he did not think the light was of so much importance as some people seemed to think. He did not believe that anybody was ever killed by a fall of roof because he had not sufficient light. Many persons got killed by falls of roof, not because they could not see it, but because they looked at it and misjudged the security of the roof. The lamp was not the subject of any patent, and he would be glad if anybody could improve on it in the direction he had pointed out.

In answer to Mr. B. Pickard,

Mr. HALL said the lamp was nearly as good as the Mueseler lamp in regard to light. It gave a much whiter

flame than an ordinary Davy lamp, on account of its burning in a chimney. Replying to the Chairman, he said the object of the small glass inside was to prevent the current of air flowing on to the gauze. The lamp kept on burning the same as an ordinary Davy in an explosive atmosphere.

Mr. TEALE: Is not the principle the same as that of a Stephenson lamp as regards ventilation?

Mr. HALL: Very nearly, except that the air is lifted up by the inner glass.

Mr. TEALE thought there was a danger of the lamp getting over-heated, and expressed the opinion that the lamp would explode sooner than the Stephenson lamp.

Mr. HALL said the lamp had been subjected to a severe test, and it did not show any sign of exploding or of overheating the glass.

Mr. MERCIER observed that in the Stephenson lamp the air goes to the gauze directly, whereas in Mr. Hall's lamp it could not do that.

Mr. HALL said the gauze was in this case a little smaller than in the Stephenson lamp, and the glass was larger.

Mr. H. BRAMALL (Pendlebury) said the Stephenson lamp did not depend on the gauze for its safety. The air was admitted below the flame, through openings, which were of such a size that their effect in resisting the passage of flame was the same as if they were holes in gauze, and it was not safe. The great drawback, to his thinking, of

shielded Davy lamps was the diminished light. Now, the use of a lamp was to afford light to work by, but people had gone on shielding the Davy till very little light was left. They could not overcome the prejudice of colliers against safety lamps unless a good light was provided. Taking all things into consideration, he had come to the conclusion that the best lamp was the Marsaut lamp. He agreed with Mr. Hall that the commonest risks were met with in testing for gas in still atmospheres or when bodies of gas travelling at gentle speeds came in contact with a lighted lamp, and what was wanted was a lamp that will afford safety under such circumstances, while able also to withstand considerable velocity.

Mr. C. PILKINGTON (Haydock) admitted that it was necessary to have a lamp that was safe in still air of an explosive nature. Still they had to guard against extraordinary occurrences, and as there may be falls of roof which would drive out a current of gas, there ought to be a lamp which will stand a high velocity. Otherwise it would not be a safe lamp. At Haydock several kinds of lamps were in use, but the Marsaut found most favour.

Mr. TEALE remarked that there are between 250 and 300 different kinds of lamps, and that amongst the confusion and multitude of thoughts it was most difficult to arrive at a solution of the problem. He suggested that the parties most interested in the matter should state precisely the conditions which they wanted a lamp to fulfil, and then if a lamp were produced which met those requirements, they should accept it, and not subject it to all sorts of tests which were never met with in the actual working of a mine. Mr. Teale also pointed out a few things which, in his opinion, were disadvantages in the Marsaut lamp.

Mr. B. PICKARD expressed the view that the presence of so much glass about the lamp was a disadvantage, as it was so liable to get broken. He thought, at the same time, that an effort should be made to improve the illuminating power of the coal-miner's lamp, and for that purpose he preferred the mineral oil to the vegetable oil. He considered that the Marsaut and the Mueseler were very effective lamps.

Mr. HALL briefly replied, after which a vote of thanks was accorded to him for his exhibition and description of the lamp, and the meeting terminated.

The discussion on Mr. Mercier's Paper on "Dust in Mines," postponed to the next Wigan Meeting.

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MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XIX. SESSION 1886-7.

The ORDINARY MEETING of the Members was held on Tuesday, February 1st, 1887, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

Mr. HENRY HALL, H.M. Inspector of Mines, in the Chair.

NEW MEMBER.

The following gentleman was balloted for and unanimously elected an Ordinary Member of the Society:—

Mr. WILLIAM CAMPBELL, Sutton Heath Collieries, St. Helens.

The following are the recent additions to the Library:—

Belfast Natural History Society: Report and Proceedings, 1885-86.—*From the Society.*

Chesterfield and Midland Counties Institution of Engineers: Transactions, Part 4, Vol. XV.—*From the Institution.*

Edinburgh—Royal Physical Society: Proceedings, 1885-86.—*From the Society.*

Glasgow—Geological Society of Glasgow: Transactions, Part 1, Vol. VIII. Catalogue of Library, 1886.—*From the Society.*

Leeds—Yorkshire Naturalists' Union: Transactions, Parts 1-9.—*From the Union.*

London—Royal Society: Proceedings, Nos. 247-9.—*From the Society.*

London—Institution of Mechanical Engineers: Proceedings, Nos. 3-4.—*From the Institution.*

——— Geological Magazine, Nos. 270-272.—*Purchased.*

Manchester Association of Engineers: Two Pamphlets.—*From the Association.*

Midland Institute of Mining Engineers: Transactions, Part 84, Vol. X.—*From the Institute.*

Mining Institute of Scotland: Transactions, Parts 6 and 7. Glossary of Scotch Mining Terms.—*From the Institute.*

Salford—Thirty-eighth Annual Report of Museum, Libraries, and Parks Committee.

Notes on "Cone-in-Cone" Structure, by W. S. Gresley. Pamphlet.—*From the Author.*

Origin of Mountain Ranges, by T. Mellard Reade.—*Purchased.*

Geology of Yorkshire Coal Field, by A. H. Green and others (Survey Memoir).—*Purchased.*

Belfast Natural History Society: Proceedings, 1871-2 to 1873-4.—*Presented by W. Whitaker, F.G.S.*

U.S.A.: Geological and Geographical Survey of the Territories: Bulletin, Nos. 2-6, Second Series; Bulletin, Vol. IV., Nos. 1-4; Bulletin, Vol. V., Nos. 2-4. Catalogue of Publications, Geological and Geographical Survey. Sketch of Origin and Progress of Geological and Geographical Survey. Proceedings of Academy of Natural Sciences of Philadelphia, Part 3, 1878; Parts 1-3, 1879; Parts 1-3, 1880; Part 2, 1881. Six Pamphlets on Water Supply, etc., by W. Whitaker, F.G.S. One Pamphlet on Bournes, by H. H. French. Travels in the Tarentaise, by R. Bakewell; 2 Vols. Geological Pamphlets by C. Prévost; 1 Vol. *Presented by W. Whitaker, F.G.S.*

Canada: Geological and Natural History Survey of Canada, Annual Report, Vol. I., 1885. Maps to accompany Annual Report, 1885.—*From Dr. A. R. C. Selwyn.*

U.S.A.: Cambridge—Annual Report of Museum of Comparative Zoology, Harvard College, 1885-86.—*From A. Agassiz.*

——— Geological Survey of Pennsylvania: Annual Report, 1885; Atlas to accompany the above.—*From J. P. Lesley, State Geologist.*

——— Philadelphia: Journal of Franklin Institute, Nos. 732-733.—*From the Institute.*

——— Washington: United States Geological Survey: Bulletin, Nos. 27-29.—*From the Government.*

Paris: Catalogue Illustré des Coquilles Fossiles des Environs de Paris, by M. Cossmann. Revue de la Legislation des Mines, Sep.-Oct., 1886.—*Purchased.*

Halle: Leopoldina; Vol. XXI. Leop. Carol. Deutschen Akademie der Naturforscher, Band. 48, No. 3. Tertiärflora, &c.—*From the Academy.*

Roma: Atti della Reale Accademia dei Lincei; Rendiconti, Fasc. 10-12, Vol. XI.—*From the Academy.*

St. Petersbourg: Bulletin de l'Académie Impériale des Sciences, Tome 31, No. 2. Mémoires, Tome 34, Nos. 5-6.—*From the Academy.*

Australia: Gold Fields of Victoria; Reports of Mining Registrars, 30th September, 1886.—*From the Government.*

FALL OF ROOF IN A MINE AT LITTLE LEVER.

Mr. M. STIRRUP (Honorary Secretary) called attention to some specimens on the table, and said that in a recent number of the *Manchester Guardian* there appeared a paragraph giving an account of a fall of roof in a colliery at Little Lever, near Bolton, belonging to Messrs. Fletcher, by which one man was killed. The stone which fell was supposed by the writer of the paragraph to have been a meteorite. He (Mr. Stirrup) wrote to Messrs. Fletcher to ask if they would be so good as to send him fragments of the stone, and he very soon received from them the specimens which lay upon the table, together with some particulars in writing. The following was Messrs. Fletcher's communication:—

Stopes Colliery, Little Lever, near Bolton,
January 11th, 1887.

On Thursday, December 30th, 1886, a fatal accident happened to a man named John Kay, by a fall of roof. A son of his was working beside him and asked him to sound the stone above his head; he did so, and said it was quite solid; in a few seconds Kay was killed by the stone falling upon him.

The stone, which was composed of a black shale coating, the coating varying from one inch to two inches in thickness, and the rest of it white sandstone, gave it a very solid sound. The dimensions of it were 7ft. long, 4ft. 6in. wide, and 2ft. 4in. at the thickest part; the other side ran out. It is thought the stone fallen is about one-half of the whole. It is very hard, and about two tons in weight. Some of the

shale round it was very black, and of a polished nature; it could be rubbed in the hands, and felt like grains of corn.

From inquiries made, these stones are not plentiful at Stopes Colliery, only seven having been seen altogether, one at about sixty yards further on the road than where Kay was killed; the size was 9ft. long by 7ft. wide and 3ft. thick.

Another is to be seen in the same level fifty yards nearer the shunt; it is 6ft. wide, length and thickness not known.

Another one, four yards lower down, presented itself, but only 3ft. diameter; thickness not known.

Some years ago, two were found in a level at a point about five hundred yards from the four just mentioned, these two close together, only a few inches separating them. In length of time the larger one of the two had to be removed, then it was found to be 6ft. thick in the centre, the width was about 10ft., the length is not known because one end was on the coal in the higher side of the level, and the other end on the lower side; that piece of stone on the higher side was 2ft. in the thickest part, and that on the lower side was 4ft. thick.

The other one, close to it, was only about 2ft. 6in. diameter; the black shale came off it; the other part was found to be white sandstone.

At a distance of about 450 yards west of these two, one was found about 12ft. long, 9ft. wide, and 6ft. thick; all the others had partly embedded themselves in the coal, except the two smaller ones, but this one displaced the coal altogether, the men worked the coal all round it, then it had the appearance of a huge boulder.

None of these stones have been known to fall before; when wanted down they have had to be blasted.

On Friday last piece of stone was sent to you as requested.

Yours truly,

JAMES SEDDON.

Mr. STIRRUP said that, knowing some of the members were occupying themselves with the subject of the occurrence of boulders in coal seams, he thought the so-called meteorite would turn out to be one of them, but the specimen before them with the polished carbonaceous coating was apparently a fine-grained sandstone, slightly micaceous, whereas the boulders he had previously seen from the Lancashire coal-

field had usually been quartzite. He asked Mr. Wild for his opinion.

Mr. WILD said that specimens like those exhibited were not boulders, and represented merely little patches, or pockets, of sandstone. He had met with such instances in the mines at Bardsley, and had also seen them near Burnley, where they would sometimes start from a feather-edge and thicken out to two or three feet—a tough white sandstone. They were not unfrequently found with a raised centre; this arose from the fact of their hardening sooner than the soft mud that lay above them; they had sunk in the coal and held position in the roof through hardening before the shale. It was a mistake to call them boulders. They are sometimes stratified as if current-bedded, the lines of stratification being unconformable to the bed of coal, or the shale roof, by which they are surrounded, occasionally to the extent of 45 degrees, and in many cases contain impurities of pyritous matter, probably derived from the underlying substance which should form the future coal-bed on which they are deposited.

Mr. STIRRUP: There are marks of rubbing, apparently on this.

Mr. WILD: Yes; it is merely caused by the friction from compression of the softer sediment around it, after partial consolidation and superimposed weight.

Mr. BURROWS: But in many mines there are much deeper groovings than these—the Trencherbone particularly. The coal is grooved as if by a glacier.

Mr. WATTS: It is unusual, I think, for a practical person not to be able to detect by sounding when the roof is about to give way. My experience goes thus far—that if the stone be loose there is little or no difficulty in detecting that it is loose, except when you are dealing with a huge mass. Then it may be somewhat difficult. I should advise a more extended sounding—not a mere tapping just over head, or

to right or left—my impression being that if the men were instructed to extend their tapping over a larger area they would be able to detect any looseness which may exist in the roof. But at first it is difficult to get an idea by this means in a soft material, more so than when you are dealing with a hard rock.

Mr. C. E. NEWTON: These things are rather common in the Forest of Dean coalfield, and are looked upon merely as sandbanks, as Mr. Wild has said, nothing more.

Mr. STIRRUP said Mr. Burrows had spoken of scoring and rubbing shown upon the coal itself. What would he suggest was the cause of that?

Mr. BURROWS said he could hardly tell; but the Trencherbone, where the scorings were most perceptible, was a good deal cut up with faults.

The CHAIRMAN said the stone before them had a very familiar appearance. He had frequently seen similar blocks; but he never quite knew how they came to be so slippery on one side.

Mr. STIRRUP said they would all like to have that explained. He asked Mr. Wild if the scorings on what might be called the true boulders—that was, the quartzite—were different in character from the rubbings on such a piece of rock as this.

Mr. WILD: No; there are no scorings, that I have seen, on the boulders, except what may have arisen from the settling of the shale around the hard boulder, giving a slightly striated character to the carbonaceous film by which it is coated.

Mr. STIRRUP: You consider the cause the same?

Mr. WILD: Yes.

Mr. STIRRUP: Not due to ice, as has sometimes been suggested?

Mr. WILD: Not in their present position. On the coast line, from where they have probably been washed away,

they may have been grooved, but there is nothing likely to groove them in the mine, being surrounded only with fine shale. With reference to sounding the roof in broken beds of rock, Mr. Wild remarked upon the effect of temperature in deep mines. The rock, he said, might sound quite solid when thus tested, but the heat of the mine might, by unequal expansion, cause a slip, of which they would not have the least warning.

Mr. Burrows said if a man was sounding in the roof above his head, and there happened to be a layer like this of which a sample was before them, it would sound quite hollow. He knew cases, however, where the roof, being in a large stone, had been sounded without any danger being detected; but he (Mr. Burrows) had detected a line which he thought indicated a pot-hole, and had caused it to be propped. When those props were removed the roof had fallen—a mass weighing four or five tons.

Mr. Watts said that if after once sounding a place they would return to it and sound it again the men might detect any looseness in the roof. It was only by the ear those faulty places could be discovered. They no doubt required a good deal of looking after. He had to do with a lot of men who were reckless as to danger, and if he did not keep his eyes open to their danger accidents would be of frequent occurrence. Here was an instance: He cautioned some men who were drilling in a deep trench to be very careful, as the sides did not seem to him to be very sound. He told them that they must keep their eyes open. He did not sound the sides himself, but that afternoon a piece of rock fell and broke the back of one of the workmen; and that very piece was one which he had sounded at a prior date. It was a triangular piece, running into the sides, and he had doubtless sounded the thick end. If he had gone a little lower he would probably have detected a difference in the sound.

THE GEOGRAPHY OF BRITAIN IN THE CARBONIFEROUS PERIOD.

The CHAIRMAN said, the next business on the paper was the discussion on the President's address, given at a former meeting, on "The Geography of Britain in the Carboniferous Period." The President being absent, he did not know whether it would be advisable to enter upon the discussion at that meeting.

Mr. STIRRUP said he had received from Mr. G. H. Kinahan, of the Irish Geological Survey, a communication on "The Extent of the Carboniferous Sea, as regards Ireland," as a contribution to the discussion.

THE EXTENT OF THE CARBONIFEROUS SEA AS REGARDS IRELAND.

BY G. H. KINAHAN, M.R.I.A., ETC.

It is still an open question how much of Ireland was uncovered in Carboniferous times—that is, *when the sea was at its maximum area.*

The Carboniferous rocks of West Cork were crushed and folded at the same time as the associated Devonians and Silurians (*Glengariff grit*). We may, therefore, presume they at the time formed a sequence, as I have pointed out in previous writings. On account of the great difference between the Carboniferous rocks of West Cork and those of Central Ireland it would appear as if these must have been separated from one another, except to the south-east, by a ridge of land.

The Western Connemara and Mayo highlands must have been covered by Carboniferous rocks. If you look at them from the south or the east you will observe—as I think was at first pointed out by Jukes—that at one time they formed a slightly undulating swelling plain that gradually sloped south-westward, eastward, and northward ; and then, again,

gradually rising northward. This plain was once the bottom of the Carboniferous sea, as on it in places are outlying patches of Carboniferous rocks. Benbeola, or the highest summit in Bennabeola, is 2336 feet* To the north-eastward of it is the massive table-topped hill called Formnamore, 2239 feet, on which in several places are outlying patches of Carboniferous conglomerate; while north-eastward and eastward, on lower ground, are other patches. To the south-westward of Benbeola you find Carboniferous conglomerate on Illion (1962 feet), Derry (902 feet), Boocaunmore (about 300 feet); and about 50 feet at Oughterard, where there are limestones on it. To the south-west of Benbeola they also occur, but on low ground.† On the hills to the north of Clew Bay I am not aware of any such outliers having been recorded; but as the higher ground to the south of the bay was covered, it is probable these were covered also.

The West Ulster highlands have not the marked outline to be seen in those of Connaught. But in them in various places are patches of Carboniferous rocks of the "Ulster type." This class of rock evidently at one time extended through the hills from Donegal Bay to Loughs Swilly and Foyle, and thence southward. They consist of red conglomerates and sandstone, yellow sandstone, shales (in places like Coal measure shales), and limestones. The red beds are only in area of small dimensions, while the others are mixed up. The first were shingle beaches that had accumulated in favourable situations, while the others seem to have been more or less shallow water accumulations. It is therefore possible these highlands may have been an archipelago in Carboniferous times.

The highlands of south-east Ulster (Mourne Mountains)

* On most of the published geological maps Benbaun is incorrectly given as 2395 feet high, while it is, correctly, only 2305 feet.

† Geological Survey Maps (sheets 84, 93, and 94), published under Prof. Hull, Director

are evidently part Carboniferous, as proved by the granite intrude.

The Leinster highland may possibly have been land at this time. The newer granite intrudes in them must be either of Devonian or Carboniferous age. But if the latter, they may have been only elevated at that time. Oldham mapped small patches of conglomerate in places on the western slopes, while formerly in one place on the Dublin hills was a small patch of Carboniferous limestone, which long since, on account of its value to the natives of the region, has been converted into lime. A few years ago in the valleys and on the hill slopes to the southward of Lugnaquillia I observed a red ferriferous conglomerate. This possibly might be the basal conglomerate of the Carboniferous, but it is also possible that it may be a peculiar form of the conglomerate so prevalent in Wexford and Wicklow between the Esker Sea and the Glacial drifts. The conglomerates in these localities, however, occur at a higher lever than the Esker Sea drift is usually found in that area, they possibly are auriferous, as in the stream from them "eyesills" of gold have been found. Even if these conglomerates are of Carboniferous age, it has been proved that some land must have existed hereabouts, as considerable pieces of Leinster granite have been found in the Dublin Calp (Carboniferous) at Kimmage and other places.

The isolated hill groups, such as Slieve Aughta, Bernagh, Arra, Felim, Bloom, and others of less note, have an appearance as if they might have been islands; the Carboniferous rocks around them being in general so flat. But creeping up them, and in some of the hills nearly obliterating some of the older rocks, are the Lower Carboniferous Sandstones. From the above notes it will appear that the Carboniferous sea must have had a larger area than that depicted inaccurately on the published map.

It was decided to postpone the further discussion of the President's address to a future meeting.

GEOLOGICAL SKETCHES AT PIETHORN AND DENSHAW.

The CHAIRMAN said the next business would be the discussion of Mr. Watts's paper on the "Geology of Piethorn and Denshaw." Perhaps Mr. Watts might have something to add to his former communication.

Mr. WATTS said: I may remark that my "Sketches" are merely sketches—scraps of observation that have presented themselves in passing through the district from time to time. I have made no effort to speculate, but have given you simple facts of local phenomena.

Mr. STIRRUP said: I should not like Mr. Watts's paper to pass without discussion, and I was hopeful that some gentleman, acquainted with the district, would have been present to-day, and have gone into the matters referred to. The paper I consider to be a very valuable one, because it is a statement of what the writer practically comes in contact with from day-to-day. It is valuable not only for present discussion but for future reference. The only point I should, myself, wish to refer to at present is the glacial phenomena. Mr. Watts says that he has not been able to meet with glacial striations in these valleys. Such striations have, however, been met with in Rossendale, on rocks of similar character to those met with in the Saddleworth district. In a bed of very hard shale, belonging to the Millstone Grit series, there have been found well-defined glacial striæ running in the direction of the valley between Bacup and Waterfoot. I should, therefore, expect them to be found elsewhere, although, as Mr. Watts says, they are likely to be readily obliterated in sandstone rock. It is only upon rocks, from which the covering of soil has been lately removed, that they are likely to be met with. Then, with regard to the drift deposits found in these valleys, sometimes at a height of 850 feet above the sea, I think we may be quite certain

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shale round it was very black, and of a polished nature; it could be rubbed in the hands, and felt like grains of corn.

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Some years ago, two were found in a level at a point about five hundred yards from the four just mentioned, these two close together, only a few inches separating them. In length of time the larger one of the two had to be removed, then it was found to be 6ft. thick in the centre, the width was about 10ft., the length is not known because one end was on the coal in the higher side of the level, and the other end on the lower side; that piece of stone on the higher side was 2ft. in the thickest part, and that on the lower side was 4ft. thick.

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On Friday last piece of stone was sent to you as requested.

Yours truly,

JAMES SEDDON.

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Mr. WILD said that specimens like those exhibited were not boulders, and represented merely little patches, or pockets, of sandstone. He had met with such instances in the mines at Bardsley, and had also seen them near Burnley, where they would sometimes start from a feather-edge and thicken out to two or three feet—a tough white sandstone. They were not unfrequently found with a raised centre; this arose from the fact of their hardening sooner than the soft mud that lay above them; they had sunk in the coal and held position in the roof through hardening before the shale. It was a mistake to call them boulders. They are sometimes stratified as if current-bedded, the lines of stratification being unconformable to the bed of coal, or the shale roof, by which they are surrounded, occasionally to the extent of 45 degrees, and in many cases contain impurities of pyritous matter, probably derived from the underlying substance which should form the future coal-bed on which they are deposited.

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Mr. BURROWS: But in many mines there are much deeper groovings than these—the Trencherbone particularly. The coal is grooved as if by a glacier.

Mr. WATTS: It is unusual, I think, for a practical person not to be able to detect by sounding when the roof is about to give way. My experience goes thus far—that if the stone be loose there is little or no difficulty in detecting that it is loose, except when you are dealing with a huge mass. Then it may be somewhat difficult. I should advise a more extended sounding—not a mere tapping just over head, or

long known and utilized in China. In the district of Tsien Lum Taing it is stated there are gas wells 3,000 feet in depth, the gas being piped through bamboo rods, and burned with clay burners. This supply is supposed to have been discovered centuries ago while sinking artesian wells for brine.

The Chinese method at present in use for drilling their wells is a primitive form of the old "jumping rods." As it is not generally known, I may be excused giving Abbi Hue's description as copied into a late number of the *Chicago Mining Review*:—

"If there is a depth of three feet or four feet of soil on the surface, they plant in this a tube of hollow wood, surmounted by a stone, in which an orifice of the desired size of three or four inches has been cut. Upon this they bring to work in the tube a rammer of 300 or 400 pounds weight, which is notched and made a little concave above and convex below. A strong man very lightly dressed then mounts on a scaffolding and dances all the morning on a kind of lever that raises this rammer about two inches, and then lets it fall by its own weight. From time to time a few pails of water are thrown into the hole to soften the rock and reduce it to pulp. The rammer is suspended to a rattan cord not thicker than your finger, but as strong as our ropes of catgut. This cord is fixed to the lever, and a triangular piece of wood is attached to it by which another man, sitting near, gives it a half turn, so as to make the rammer fall in another direction. At noon this man mounts on the scaffold and relieves his comrade till the evening, and at night these two are replaced by another pair of workmen. When they have bored three inches they draw up the tube with all the matter it is loaded with, by means of a great cylinder, which serves to roll the cord on. In this manner these little wells or tubes are made quite perpendicular—to a depth of from 1,500

feet or 1,800 feet French—and as polished as glass. When the rock is good the work advances at the rate of two feet in twenty-four hours, so that about three years are required to dig a well."

The following extract from the same paper, of November 18th, is interesting:—"Gas wells are 5⅝ inches inside diameter, and average 1,500 feet in depth. It costs 8,000 dollars to 6,000 dollars to drill and 'case' a well. The pressure at the mouth of the well varies from 40 to 1·288 pounds to the square inch, and with this range furnishes sufficient carbon to substitute 50 to 1,000 tons of coal daily; in the pipe ways, notwithstanding the great friction, the gas travels at the rate of 6⅝ miles a minute."

In November, 1875, the first Natural gas was used for smelting iron, by Spang, Chalfant & Co., Pittsburg.

The wells at New Cumberland, W. Va., have supplied gas for more than twenty years for the manufacture of bricks. The East Liverpool wells have been running for twenty-five years, and are still productive. At Leechburg and Apollo, the gas has been used in heating—and puddling—furnaces since 1872. At Beaver Falls, Natural gas has been used since 1876 in the cutlery works, but about two years ago the gas failed, presumably on account of the wells becoming obstructed by more or less solid matter. The Butler county oil field was the first in which the large productive wells of Natural gas were struck. The mill of Spang, Chalfant & Co. has been supplied from this field since 1875. In 1877, the first well, known as the Haymaker Well, was bored at Murraysville. It was not until 1883 that this immense storehouse of potential energy was made useful by Pew & Emerson, who laid a line of pipe from the Murraysville Well to and into the city of Pittsburg. In June, 1884, the celebrated Westinghouse Well, located in the Twenty-first ward of the city of Pittsburg, struck the gas at a depth of about 1,600′.—*Chicago Mining Review.*

Natural gas seems to have been known in America before the advent of the "white man," such as the "burning water" of Niagara and elsewhere; and it is now some years since the gas well, first considered of importance, was struck in the Kananha Valley, West Va., while boring for salt water. Gas had previously been found in other borings for salt, but was ignored, as it is only in the last two years that the great gas industry has been created.

As stated by Professor Wurtz, the gas, wherever found, "is Marsh gas, that hydro-carbon of all others which contains the most hydrogen and the least carbon, the compound which naturally and necessarily forms the first residue of the abstraction of carbon from organic matter by the powerful oxidizing agent, since in nature we scarce find elementary hydrogen as such a residue. Now, what oxidizing agents are there, or, rather, what have there been in all these rocks that would effect such a combustion? I reply, oxides of iron, now represented in these rocks by iron sulphides, showing the iron oxides to have passed through the form of sulphates, an action similar to that evolution of marsh gas going on in every stagnant pool loaded with vegetable matter and blackened by sulphide of iron, which is occupied in conveying the oxygen of the water to the carbon of the mud."

In connection with this subject it may be mentioned that Captain Phillip Argall, after he had placed wooden landers in the Upper Cronbane Mine, Ovoca, Co. Wicklow, in which to precipitate the copper from the mine water, found that the process generated Marsh gas in the levels, so that the landers had to be visited with safety lamps.

Two years ago, besides the Marsh gas in the American "fiery coal seams," it was also known to occur in other strata. In the Dominions it had been found in Primordial *(Cambrian)* or Ordovician *(Lower Silurian)* strata between Quebec and Montreal; at Niagara, in the Silurians (?), and

in Assiniboia in either Cretaceous or Cainozoic Strata. In the States the great find seems to have been in the rocks over the great shale formation of "Devonian and Sub-carboniferous rocks" of Pennsylvania and New York. It had, however, been also found in Ohio by adventurers who had drilled in the continuation of those rocks and in the Ordovician *(Lower Silurian.)* Since then, however (that is, within the last two years), the payable gas in the rocks of Ohio, on account of the great number of trials put down, has in a great measure been localised; and the principal supplies are found to be confined to portions of the "Berea grit" which "overlie or are interstratified with" the great shale formation of "Devonian and Sub-carboniferous age," and in certain places in the upper beds of the *Trenton Limestone* (Ordovician.)

By the recent trials it is proved that oil and gas are adjuncts—the first, however, being heaviest, is below; and when two cisterns are connected, one being a little higher than the other, in the lower one will be found gas and oil, and in the upper perhaps only gas. Paying gas has only been found under certain conditions. As there must be;—a *supply*, a *reservoir* and a *cover*, to keep in the gas, of a more or less impervious rock, generally fine-grained shale. Also the rocks must be nearly horizontal or dip at gentle angles, and the thicker the cover the greater the supply. In the later Ohio rocks (that is, the Berea grit), the source is in the black carbonaceous shales which belong to the so-called Devonian or Sub-carboniferous, the reservoirs being distinct from the source. As the Berea grit approaches its outcrop, and the cover becomes thin, the gas supply gradually decreases until eventually it ceases. As the source of the second supply is in the Trenton limestone, the source and reservoirs are continuous. Nowhere in Ohio does this limestone come to the surface, therefore it always has a good thickness of "cover;" but at the same time it does

not always contain a paying supply, the most productive wells being near the upper edge of a slope which joins two horizontal terraces of the limestone. Similarly in the Berea grits; "slight rolls traverse it, breaking up the monotony of its descent, and these rolls or interruptions of dip connect themselves at once with gas and oil accumulations." Gas and oil are also found on other horizons, but not in paying quantities. The Trenton limestone was first discovered to be a store-house of high pressure gas at Findlay, in November, 1884, and now yields both gas and oil in at least three counties of northern Ohio, namely, Hancock, Allen, and Wood. Fuller details will be found in the previously mentioned paper by Professor Orton in *Science*, June 25, 1886.

From John Wallace we learn that in the Baku district on the Caucasian side of the Caspian Sea the *cisterns* for the petroleum are either a friable sandstone or a mass of sand, "sandpockets," as sand comes up with the oil; while the *cover* is a hard blue clay. If there is a leak or fault in the cover the gases and oil escape, and the gas, if ignited, will burn for centuries; "this may be seen in various places at Suroehani, near Baku, where one of the oldest Parsee Fire Temples in the world is built over a gas well." If the oil escapes when it comes to the surface, "the lighter and more volatile part evaporates into the atmosphere, leaving a thick tarry mass known as bitumen, which has been found from time immemorial in various parts of the world, and which the ancient Egyptians procured at Jeb el Zeit, on the shore of the Red Sea, for the purpose of preparing and preserving their mummies. Jeb el Zeit has recently been the scene of borings by the Egyptian Government; but, up to the present, with only partial success." In connection with this extract from Wallace's paper, it may be mentioned that Bristow, in his "Mineralogy," records bitumen (*asphalt*) as occurring in the Binney Quarries, near Edinburgh, and in Derbyshire, near Matlock, and in the Odin Mine.

After this long introduction, I may come to the subject, the special object of this communication. The success of the gas wells in Ohio has led adventurers to turn their attention to the fiery seams of coal; and these, we learn from the *Chicago Mining Review* and other sources, are now being experimented on. The promoters propose to put down a number of bore-holes, and by them to abstract the gas; they expecting that thereby they will not only make the working of the coals safe, but also create a new industry, as the gas so obtained, if in quantity, is to be treated similarly to the gas from the present wells, that is, it is to be sent by "pipe roads" to centres of industry, there to be utilised.

It appears to me that the "Old Country" should also make experiments. The Ohio borings, so far, prove that gas should accumulate, if there is a source to produce the gas, with an impervious and thick cover; but it seems also necessary that the strata ought to be nearly horizontal,—with in places,—gentle rolling curves. As far as the Irish Ordovicians are concerned there are in them strata more or less like the oil and gas rocks of Ohio Ordovicians, as in those of the Co. Cavan. Some of these are so like, not only the Ohio, but also some of the Canadian rocks,that in a paper on "Irish Metal Mining," recently read before the Royal Geological Society, Ireland, I suggested that trials for oil and gas might be made by boring. There are also places in Wexford and Wicklow with good-looking strata. Unfortunately, however, nowhere is bitumen recorded as a surface deposit; whilst all these Irish strata are, in general, folded at high angles; yet, in the troughs of the folds there are places where the "liquor fuels" might be found concentrated; the gas possibly may have escaped, but the oil being heavy may have remained.

The Berea grits are somewhat like the English Trias and Permian and produce salt, especially the "Logan conglomer-

rate." In China and America gas appears to have first been met with while boring for brine. I cannot, however, learn of any records of gas having been met with in the Salt mines of the "Old Country." In connection with the English Trias there ought to be a "source" in the underlying coals and Carbonaceous shales, and in the Triassic "reservoirs"; but the impervious "cover" may, in places be wanting, but surely not always. Marsh gas, however, with a "cover," does occur in the fiery coal seams, and often in inconvenient quantities. Here, therefore, there seems to be an open field for the adventurer, for the gas, at the present time, ought not to be only a source of danger and expense. This seems to be a fair field for enterprise, as any undertaker would not go into the adventure perfectly blindfolded, having the American experience as a guide. The wells in Ohio teach, that the accumulation of gas in each successive gas bearing stratum, is within certain limits; that is, on or near the top of the roll in slightly undulating strata. There is an interesting question, to which I would call the attention of those conversant with the English coal. It is: In what parts of a "fiery seam" is there the greatest accumulation of gas? Is it, as in the Ohio gas beds, near or at the top of a rise or roll in the dip? If this law hold good in the fiery seams, the work in a measure would be minimised, as the gas well should be put down on such rolls.

Both gas and oil rise naturally by what has now received the name of "rock pressure" to certain heights; while high presure gas comes off unaided by any artificial means. In connection with the fiery coal seams we have to enquire; Would the abstraction of the Marsh gas pay? At the present time there is the loss of life due to explosions, and the additional expenses due to the precautions necessary in working such coals; and if the one could be prevented and the other got rid of; How much would be gained? In addition to these, there is also the prospect that the gas

abstracted would be in sufficient quantities to be the source of a new industry.

It must be allowed that it is very hard to introduce a new industry into an "Old Country," more especially when it creates a revolution. I am old enough to remember how long it took to replace the old oil lamps in the towns by gas; while at the present time there are many towns so naturally situated as to be capable of being cheaply lit by the electric light, which still stick to the gas. This, indeed, may also be seen in America, both in the States and Dominions, as there the new towns, even in the Prairies, seek the new light, while the old ones are content with their present darkness. To teach the English to substitute "fluid" for "solid fuel" would probably be uphill work; still, it ought to be possible, when we consider the rapid changes that have taken place in Pittsburg, in less than four years, the new gas fuel having reduced the old coal supply somewhat over 3,000,000 bushels.

It seems scarcely necessary to add, if the gas supply from the fiery coal seams was in sufficient quantities to pay, that in the same way as in America at the present day, and in China for centuries, the gas from the wells could be carried in "pipe roads" to a central depôt, from which to be dispersed to the various consumers.

As Natural gas has been very little studied in the Old Country—in fact it seems to have been perfectly ignored—and as the object of this paper is to bring it into notice, it may be allowable to give additional facts to those already culled from the United States papers. In connection with the composition of these natural gases the *American Manufacturer* points out that the published analyses are very conflicting, as, according to these analyses, some gases contain no nitrogen, while others have as much as 23·5 per cent. In an analysis by Mr. Ford the hydrogen from one well ranges from, in round numbers, 27

to 35 per cent., all the eight gases, marsh gas, ettylic, hydride, olifiant, carbonic oxide, hydrogen, nitrogen, and carbonic acid being present; another analyst stated that this gas only contains marsh gas and carbonic acid with traces of hydro-carbons; while another stated it contained hydrogen, marsh gas, and oxygen. The writer goes on to point out that these great differences are due to the mode of collecting the gas, as the gas got at depth is different from that at the well's mouth, and that the latter differs greatly from the gas that has travelled in a "pipe-way," in the joints of which certain constituents, especially hydrogen, may have leaked out.

The same journal has an interesting notice on the refrigerative power of these gases, and states that "even carbonic-acid gas has been solidified by the intense cold resulting from escaping gases that has been stored under high pressure." They give various cases in which water, in boring, has been frozen up on the gas strata being struck; one, however, will exemplify all. In a well in Butlers Co., Pennsylvania, during one of the warmest days in May, the borers struck gas at 900 feet; previously they had struck water at 600. When trying to draw the tools they came up easily 300 feet, where they stuck so fast that they had to cut the rope and let them fall to the bottom. When afterwards with another set of tools they bored the hole, they found a plug of ice at the 600 feet, due to the gas having frozen the water.

A desultory conversation took place on the subject of Mr. Kinahan's paper, the Chairman pointing out that in all cases where bore-holes had been sunk down to the coal, the amount of gas given off had been very trifling. The difficulty was also mentioned of the great cost of boring in this country, as compared with the United States.

It was agreed that the discussion of the paper should be taken at a future meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XIX. SESSION 1886-7.

EXTRA MEETING AT THE OWENS COLLEGE.

At an EXTRA MEETING of the Members of the Society and their friends, held in the Mineralogical Museum Room of the Owens College, on Friday evening, 4th February, 1887.

The President, Professor W. BOYD DAWKINS, M.A., F.R.S., in the Chair.

The PRESIDENT said: Before I call on Mr. Kendall to give the paper which he has promised on "The Carboniferous Volcanoes of Great Britain," I want just to show you one or two things we have been doing in this museum, in order to make our collections more intelligible. My idea of a museum is that it should be a place in which things are arranged in such a fashion as to be understood by people who are not specialists; and, in order to do that, I have begun a system of restorations of some of the more remarkable of the extinct beasts. The first restoration which I will ask your attention to is the one which is represented, in the bones, by this very fine photograph: it is taken from a specimen which was found at Solenhofen, and it represents the very earliest of birds. It represents a bird with a

long reptilian tail, furnished with feathers—which are distinctly visible—and in the beak you will see teeth, showing that the creature was partly bird partly reptile —bird in most of its parts, reptile in length of tail and in the presence of teeth in the beak. It has been called the archæopteryx, or the ancient bird, of Solenhofen. Well, here, in this photograph, you see what looks like a mass of feathers and of bones, unintelligible and uninteresting, as I take it, to those who do not happen to know what is really meant. But suppose I ask your attention to another picture, in which you see the creature restored, you see at once how exceedingly useful such a restoration is in enabling a person to get an idea of what the creature was like in the living state. This restoration is based upon the best authorities which I can lay my hands on, and is carefully drawn, showing the bird not only as he was in the bones (which you see in the photograph), but as he was in the feathers and in the flesh. This is the sort of illustration which I hope to carry out, if I live long enough, for the main portions of this museum. Now, I will ask your attention to another illustration. No doubt most of you have read of the very remarkable discoveries made in America by Dr. Marsh, among the most interesting of which is that of some very curious birds which belonged to the period of our chalk. The archæopteryx belonged to a period long before the chalk—it belonged to the Oolites. Well, here we have a bird which belongs to the time of the chalk, and the figure I now show you is a restoration of the skeleton of the creature, whose bones, now in Dr. Marsh's collection at Yale, I have myself examined. You have, then, the creature as represented by the bones, and also drawn to life-size with the flesh and the feathers on it. These are two illustrations which I thought I should like to

place before you, just to show you that, whilst these buildings are waiting for their contents, we are hard at work trying to get something to put into them. With regard to the coal measures, I find some difficulty in restoring the ancient forests, but I shall hope to get over that difficulty. I am working through them tree by tree; some few are already drawn; and I hope ultimately to combine them into a very respectable forest. We shall then have these enormous trunks that we possess, together with one of the finest specimens yet discovered, and which Professor Williamson has secured for us,—we shall have the collections which our Society has accumulated since its formation—all arranged in the best possible manner, and with ample accommodation, and illustrated by such restorations as you see here. I thought, gentlemen, it was advisable to put before you these few things; and when we meet after next summer I hope we shall meet in a much more convenient place than this in which we are met to-night. By that time I hope we shall have a part of the Geological Museum in its proper place, and shall be able to study the fossils and know our wealth—for you must look upon these collections as held in trust for you and for the public. (Applause.) We shall now be glad to hear the address which Mr. Kendall has promised us on "The Carboniferous Volcanoes of Great Britain."

Mr. Percy F. Kendall said: Gentlemen, with very great pleasure I avail myself of the opportunity which your Secretaries have afforded me of addressing you this evening. It is with some diffidence that I approach such a subject before such an audience. I am almost a stranger in these northern latitudes, and consequently have not had the large opportunities that many of you have had of examining the carboniferous series of rocks. However, I have endeavoured

to profit by the opportunities I have had of enlarging my knowledge as much as possible by reading. Now, of course the consideration of such a subject as this, it goes without saying, is of very wide importance in the mining industries —especially coal mining. Our coal beds are very greatly affected in various ways, by the volcanic phenomena that accompanied, preceded, or followed their deposition. Thus the deposition of coal may have been affected by the presence of volcanic hills, which would forbid those conditions under which only we can suppose coal to have been formed—under swampy conditions—and, again, the deposition of good workable coal would be forbidden by the proximity of volcanic eruptions, inasmuch as the volcanic ejecta would mix with the coal and render it worthless. Again, the coal beds, subsequently to their deposition, may have been profoundly affected by the intrusion of various volcanic rocks amongst them. There is a series of specimens in these drawers which will illustrate very well the change that a bed of coal has been found to undergo in contact with volcanic rocks. Those changes are of two kinds: in the first place, there may be absolute coking, as very commonly occurs locally; on the other hand, there may be more extended conversion into anthracite. In the one case, the coal is rendered worthless as coal; in the other, it is rather improved, for mere heating purposes, but that advantage, if advantage it be, is counterbalanced by the way in which the coal is broken up and the igneous material intruded amongst it. Before I go further, perhaps I may be permitted to make a few remarks regarding volcanic phenomena, and the proofs we might expect to find of the former existence of volcanoes in this country. I am aware that I shall be traversing old ground. Several of my hearers have already heard my opinions upon the subject; and of course will, in

their own reading, have become acquainted with it. Well, I think it is necessary before I proceed to show what proofs we have of volcanic action in the carboniferous period, to point out the results which might be expected to be found in the rocks. In the first place, usually a volcano is a hill which has a central cavity, or communication with a heated portion of the earth's interior. The diagram before you shows the simplest form of such a hill. When the volcano has been built up to a certain height, it not uncommonly happens that fissures are rent in it, and these fissures are injected with molten material from below. Very frequently, when a volcano has attained to a considerable size—almost invariably, in fact—the great weight of the column of lava which has to be raised in order to overtop the edges of the crater, or central cavity, is so great that it is really easier to burst a fissure in the flanks, or even in the adjacent country. These fissures very commonly run for miles, and may be injected with molten rock; and small volcanic hills may be thrown up along the course of the fissure. Ætna frequently exhibits that phenomenon. In addition to these great dykes—these masses of material which have been injected into vertical or nearly vertical fissures—a great deal of molten rock is also injected horizontally, or approximately so: thus, if we have a series of horizontal beds, we will say with well-marked planes of stratification, it not unfrequently happens that the ascending mass of molten material sends off a leader which penetrates in this fashion—(exhibited by a sketch on the black board). Amongst the beds in the Newcastle coal field, for example, great intrusion sheets of that description have been observed which run along in a very hard coal seam, and render it utterly worthless. Then, take another case of the simple welling out of lava without the formation of a volcanic hill. The molten rock wells out

through the great fissures which have been torn—(volcanic eruptions being, I believe, invariably accompanied by earthquakes)—and floods the country in a quiet fashion, without any such violent explosion as we are accustomed to associate with our ideas of volcanoes. Examples of this may be observed very commonly in the Scotch coal fields. In welling out, this molten material follows just the same course that it would when upon a highly-inclined surface—that is, it progresses with a rolling motion. The top of the molten stream—the roof of scoriaceous lava—rolls over and forms a bed for the lava stream to be deposited on. Thus it comes about that lava streams have a cindery lower surface. These are important points in connection with the history of extinct volcanoes, because such facts as these enable us to distinguish between intrusive sheets—those sheets of formerly molten rock which have been intruded in amongst the strata in the way represented in the diagram—and those which have actually been poured out at the surface over, say, such a bed as this (illustrating it on the black board). In the former case, there will be no cindery upper or lower surface, and the beds above and those below would be baked—affected by the heated material—while in the case of a surface flow only the inferior bed would be so affected. Now, as to the earthquakes: we may, too, get a great deal of information from those. I am in hopes the time will come when we shall be able to interpret a good deal of them. We do, as a matter of fact, find "fossil earthquakes:" they are usually spoken of as "faults;" but I cannot imagine any conditions under which rocks should be rent and torn so as to produce a fissure, or at any rate a line of breakage, running for hundreds of miles, without producing a violent concussion. In dying out, volcanoes pass into a quiescent stage, when they merely throw out mud and moisture, and

finally sink down and exhale various gases. Then the work of the atmosphere comes into play, and they are gradually cut down—cut down, it may be, vertically, as in one of the diagrams—the net result may be to reduce them approximately to a level. In one of the diagrams I have represented an extinct volcano in the Island of Mull: there we have a great volcanic cone cut down almost to its very heart, and the great frozen lake which supplied the molten material to the lava streams has been exposed. By a further process of erosion and denudation they may be so completely cut down that all the lava streams, as here represented, may be removed; and there remains merely a great boss of some highly crystalline rock such as granite. These great bosses are exceedingly common in the more mountainous parts of the British Isles—for instance, in Cornwall and Devon, and in the North. If we come to consider the carboniferous period especially, we shall find that intermingled with the various members of the carboniferous series are unmistakable evidences of contemporaneous volcanic activity: in fact, the carboniferous period may be regarded as, *par excellence, the* volcanic period in the British Isles. Commencing in our own district, and with the commencement of the carboniferous period: By the kindness of Professor Dawkins, I am enabled to show you a map of the probable distribution of land and water in the lower carboniferous epoch—that is the period corresponding to that of the deposition of the mountain limestone. There was stretching across the centre of England a great ridge of land, with sea to the north and south. Cornwall and a large portion of Devon were occupied also by land; nearly the whole of Ireland was covered by sea; and Scotland, to the south of the Highland line, with little islets here and there, such as in the Isle of Man and the Lake country. At that period, we have evidences of very

great volcanic activity—activity that had persisted from the preceding Devonian times. In our own district, that is in Derbyshire, there were three great flows of basaltic lava—locally called toadstone—and they were evidently submarine flows, gentle wellings out, but they were preceded by some little violence or explosion, no doubt; and one evidence of the explosive preliminary period is the occurrence in Tideswell Dale, and two or three other places, of beds of baked mud, lying interposed between the toadstone and the mountain limestone which preceded it. This bed of mud has been baked by contact with the highly-heated molten basalt, and a beautiful columnar structure has been produced in it. The columns are, in some cases, two or three feet in length. In Ireland, at the same period, especially in the neighbourhood of Limerick, there were extensive flows of basalt, and passing further northward as far as the Scotch border, and beyond, innumerable evidences of very great volcanic activity are to be seen. Small volcanic hills occurred by hundreds in a large portion of Scotland south of the Grampians and down to the English border, extending right across Scotland from Bute and Arran through Fife. There are still remaining not merely sheets of lava but actual volcanic hills and beds of volcanic ash: the last notably at Burntisland; and it appears exceedingly probable that the Grampians themselves were a great chain of volcanoes at that time. They are now completely worn down to mere stumps. Passing from the extreme north to extreme south, in Cornwall and Devon there were volcanoes in the Devonian times, and those volcanoes were persistent on through the carboniferous times; it is therefore quite clear that at this early period in the carboniferous epoch a great cluster of volcanoes occupied nearly the whole of the British Isles. The promontories, in Cornwall,

are mainly occupied by hard igneous rocks, masses of granite that formed the old lava lakes. Proceeding from south to north, we find evidence along the line of the old ridge, traversing the middle of England from east to west, in the upper carboniferous period, that that ridge was gradually submerged, and at the time of its submergence there was a great outburst of volcanic activity, evidence of which we see in the Warwickshire and South Staffordshire coal districts. In Anglesea, during the deposition of the carboniferous limestone, as well as in Ireland, Derbyshire, and the Isle of Man, there is also evidence of volcanic activity. On the Scotch border there were volcanoes pouring forth enormous volumes of lava; and the great belt of volcanoes, stretching right across the central portion of Scotland, continued their activity into the upper carboniferous period, just as there was an outburst of volcanic activity in the Birmingham district in the upper carboniferous. You thus see that, in this period, the volcanoes were to be reckoned by scores—by hundreds probably—large and small. But the volcanic energy was gradually dissipated, and in the ensuing period, the Permian, it was hardly apparent at all; and in the earliest secondary rocks, the Triassic, the solitary relic we appear to have remaining to us is down in the neighbourhood of Exeter. Then there was a great lull, and as lulls are proverbially the harbingers of storms, a terrific outburst took place in comparatively modern times. Skipping the whole of the secondary period, a great outburst that appears to have been confined to the Western region, the North of Ireland, the Hebrides, and the great Icelandic system of volcanoes. These eruptions, though they do not properly concern the subject on which I am addressing you, did profoundly affect our coal deposits; therefore it is worth while to say a word about them. In the Northumberland

coalfield we have a tremendous system of dykes—dykes of enormous size and linear extension—great injected fissures which not improbably were connected with the great extinct volcano in the Isle of Mull, and which extend to a distance of 200 miles from the volcano. We have, in one of these drawers, a series of specimens, to which I have already alluded, taken from one of the northern coal districts where this tertiary volcanic dyke has burst in amongst the coal seams and coked them, and has crushed and mingled amongst them so that the fragments are almost indistinguishable. There is one point connected with the carboniferous volcanoes which is of some interest I think. It is still a debateable point how far the atmosphere of the carboniferous period differed, if at all, from the atmosphere of the world as it is to-day. It is beyond all dispute that enormous quantities of carbonic acid, or more properly carbonic anhydride, were abstracted from the atmosphere and locked up in our coal seams—a quantity out of all proportion to the actual amount of carbon now preserved in those coal seams; and it has been a vexed question whether or no, previous to that great abstraction, the composition of the atmosphere was very markedly different from its present condition. Now, with a great series of volcanoes in all stages of decay, from the most active to the absolutely quiescent condition, we shall no doubt have had many fuming volcanoes—those in the last stage of dissolution; and, from our experience of fuming volcanoes as they are presented to us in all parts of the world, it seems exceedingly probable that they were pouring out large quantities of carbonic anhydride. One single extinct volcano, fuming away in the Brohl Thal, has been computed to pour out 100,000 tons per annum; and no doubt there are many other carbonic anhydride springs, as we may term them, doing as great an amount of work.

There is the famous valley of the Upas Tree, in the Island of Java, and all round about the Vesuvian system of volcanoes there are springs which, no doubt, contribute largely to the carbonic anhydride of the atmosphere, and do their best to counterbalance the efforts of animals and plants to abstract it and store it away. And it certainly seems a feasible hypothesis that, at the period of which I am speaking, these very volcanoes were contributing their quota to the restoration of the balance—supplying carbonic anhydride to the atmosphere as fast as it was abstracted by plants. That, of course, is merely a suggestion which must be taken for what it is worth. Certainly the carboniferous period, so called, is not the only carboniferous period: it is the most important one to us, but in other parts of the world the "*carboniferous*" periods occurred at geological epochs long subsequent to our Palæozoic one. In America and in the northern and central portions of the European Continent the coal beds are of this carboniferous age, but in other parts there are jurassic—that is, secondary—coals, and in others tertiary coals. The latter deposits have not had time to pass through the long series of changes necessary to convert them into similar coal to that of our carboniferous epoch; but have only reached the lignite stage, *e.g.*, the brown coals of Bohemia, coals of very great importance; and in Switzerland, on many railway lines, tertiary coal is regularly used as fuel for the locomotives. Considering, therefore, the long period of time that has elapsed since the carboniferous formation, and that it was the *great* carboniferous period, and not the *only* one, I do not think it is altogether unfair to assume that the atmosphere was very much then as it is now. I have here, besides the specimens I have alluded to as illustrating the alterations of coal seams, a few characteristic igneous rocks, showing the activity of

carboniferous volcanoes in other parts of the kingdom. I have placed amongst them one or two that possibly may give rise to some comment—specimens of dyke-stones; volcanic rocks from dykes, from the great system of Cornish volcanoes; and a few undoubtedly interstratified carboniferous volcanic rocks from Scotland. Amongst these there are actual lavas and specimens of beds of volcanic ash that accompanied the outflow of the lavas from some of the Scotch volcanoes. I will not detain you with any further remarks, and I thank you for the attention with which you have listened to me.

A cordial vote of thanks to Mr. Kendall having been unanimously passed,

Mr. Dickinson said: I was not aware, when I came here this evening, what part of the subject of volcanoes Mr. Kendall was going to take up, so that I have not studied the subject at all; but I have myself visited a great portion of this very wide district over which he has conducted us. I know the Cornish bosses of granite, and I can follow him up through Wales, and on to Ireland and Switzerland and Scotland, so that what I say I can really speak from my own observation. I have been much interested, and indeed instructed, by what I have heard this evening, although one may not agree with all the views that Mr. Kendall has laid down. Now, in Scotland, for instance, I have sunk shafts down through those beds of what is there called "floating whin." They lie almost as a stratum in the coal field, but do not always maintain their regular position. It certainly is a fact, as Mr. Kendall has stated, that in proximity to these beds of floating whin the nature of the coal is almost invariably changed. In Scotland, I think, the character generally is to become anthracite,—almost as fine as that in

the western parts of South Wales. At least, such is my experience of it. There is another fact I would like to mention. I do not know any place where these beds of floating whin, or basalt, are met with unless there are those trap dykes running through the district. These trap dykes occur in the Newcastle, in the Scotch coal field; also in the Irish coal field about Ballycastle, in County Antrim. Mr. Stirrup has said that we have none of these dykes, as far as he knows, in the Lancashire coal field. I do not believe there is such a thing. I have never heard of one. We had once brought before the Society a notice of one met with out of the coal field, beyond Chatburn, and that is the only instance, so far as I know, of anything of the kind in Lancashire. We have no beds of floating whin. I think the same may be said of the main Newcastle coal field: there is no such thing as a bed of floating whin until you reach the north-western portion of it, where the coal seams lie stratified with the mountain limestone, and there the same bed of floating whin is found as the bed which runs through the lead mining districts of Durham and Cumberland. I have myself surveyed that and the Roman wall built on the top of it, north of Haydon Bridge and Haltwhistle. The out-crop of this whin may be traced for miles: on the top it is almost a regular stratified bed. The bottom of it is not seen in many places, but I remember distinctly seeing it at Tees Force, where the waterfall overflows it. This same bed corresponds with the toadstone of Derbyshire. I told you that I had myself sunk shafts through floating whin in Scotland, and worked coal above it and below it, and found the nature of the coal was taken out; but never, in any one of these workings, have I seen or heard of any crater from which the lava or whin has been emitted—only those trap dykes which run through the country, and which are

nearly vertical. I know of no other source but the dykes. I have never heard of a crater being met with in working the coal in all the extensive workings in Scotland. There may be such, but they have not come under my notice. And these dykes, instead of running at various angles, as in the section exhibited here—showing angles of 45 degs.—are almost invariably perpendicular, or nearly so, with little displacement of the strata. The strata at the sides of them are burnt, and the coal is sometimes, as Mr. Kendall told you, a perfect cinder; but apparently these beds of floating whin have been intruded, when the strata were soft, and not after the rocks had assumed their present form. One very interesting fact I might mention, which I met with in Ayrshire, where I had sunk 20 fathoms through one of these beds of whin. Two miles away from that place, the nature of the rock changed considerably, and became an almost pure siliceous rock. The floating whin is, itself, a softish, not brittle stone; it does not make a good road material, like that from the dykes—it pulverises. If put into the fire it does not fly but melts, and I have many times melted an iron button from it in a crucible with the addition of a little flux. But the subject is so wide it is almost impossible to touch upon these things. As to the Cornish bosses of granite, I cannot think they ever were volcanoes. And as to the beds of coal that are met with in Switzerland, these come in in the most curious way. You may go into one of the underground workings and find the coal varying up to 9 feet in thickness, in lenticular masses, swelling out from just merely a parting between two rocks, and disappearing again in like manner. I have never traced underneath this coal any stigmaria, such as we have underneath our coal seams here. I have many times looked for them, but could never find

any. On visiting the Mont Cenis Tunnel, during its construction, I observed a coal seam about a foot thick. They said they had passed through several such seams in cutting the tunnel. And, as to the Irish coal field, I cannot bring my mind to believe that the appearances there observed were caused at all by volcanoes. The whole of the north-eastern portion of Ireland has thick beds of basaltic rock, stratified with it in beds, corresponding to those in the south of England lying above and below the chalk. They have in Ireland been changed from some cause into a species of basalt or trap; but what that cause has been I cannot pretend to say; and have been placed in position without any material disturbance of the surrounding beds.

Mr. R. Burrows said: There can be no doubt that we have had volcanoes in the carboniferous period, and volcanic outbursts in the secondary period; but it strikes me that many of the volcanic outbursts in Scotland, Wales, and Devonshire must have been at an age long anterior to the carboniferous. I have always had the idea that those were amongst the earliest rocks we had. I do not see that the lecturer has given any grounds for the statement that the great volcanic bosses in Cornwall and Devon and the volcanic outbursts in the north-west were connected with the carboniferous period. I should like to hear something more explicit on the part of the lecturer a little later on. I may say that, on one occasion when I was down in Derbyshire, I obtained a very curious hand-specimen: it was a piece of charcoal embedded in the limestone. I got it at the foot of Mam Tor, at a spot where men had been breaking up the limestone for the roads; and when I broke the specimen in two the charcoal was perfectly iridescent. I

crumpling and contortion that is observed almost everywhere in these Devonian beds where they are in proximity to the granite. In fact, without seeing the granite, one might almost have predicted its discovery in particular regions from the contortions of the Devonian beds. It is exceedingly marked, and they have undergone considerable metamorphosis besides. I have brought with me a geological map of the Land's End district of Cornwall: between Mount's Bay and St. Ive's Bay the alteration is so great that it is hardly possible to distinguish between the two rocks. Then we have the great system of dykes—vertical fissures traversing the country for miles. They occur here in dozens, just in this one little bit of country, and they obviously have relation to that great granite mass which constitutes the Land's End peninsula; so that I think the evidence is very strong indeed that these were lava lakes—that is, underground reservoirs whence the molten rock was driven which injected all those fissures; and since the fissures traversed the water-deposited Devonian rocks, it needs no further demonstration that they are post-Devonian at least. We have the evidence of the North Devon carboniferous rocks that there were volcanoes in the near neighbourhood in active operation during the carboniferous times, and I think it is a very fair assumption that those volcanoes were situated where the great granitic bosses are. The latest outburst of volcanic activity in the British Isles between the carboniferous series of operations and the incalculably later—in years—Miocene outbreak, is in that Cornish area, showing that the volcanoes which were in operation in carboniferous times had not ceased until just at the beginning of the secondary period. With reference to the carbonaceous material in the north of Cornwall, it is necessary, perhaps, to explain the lines upon these maps.

I do not think Professor Dawkins would insist upon their rigid accuracy, within a few miles, and the extension of the upper carboniferous marsh land may have been a little further south than the colour has been carried in the map. That will explain the coal measures of the south of England. In Mr. Dickinson's very excellent and practical remarks there were two points upon which I might be permitted to say a word or two. First, as to the absence of "floating whin," that is, lava streams, in the Northumberland coal field, or in the coal workings, except where those workings have been carried down into the coal seams of the carboniferous limestone age; for it must be understood that, when Lancashire was occupied by a carboniferous limestone sea, Northumberland and the south of Scotland were undergoing great changes of level, and sometimes the upward tendency was sufficiently long to permit the formation of coal seams. Well, that I think is quite consistent with the idea that there is some connection between the volcanic outbursts in Derbyshire and that in the Northumberland coal field. The igneous rocks there certainly appear to be interbedded with the mountain limestone. I believe Mr. Dickinson's suggestion is perfectly accurate, that there are no actual craters to be seen in the Scotch carboniferous volcanoes. That can be very easily understood. When a volcano has died out, it has a tendency to be worn down. For example, in the Peak of Teneriffe we have a most beautiful cone at a very high altitude. The loose volcanic ash that built up the upper portion of the cone has been blown away, and left exposed a neck which represents the last bit of lava that it tried to pour out. Thus we have a solid column of lava standing up above the summit. Now, such necks as these are exceedingly common in the Scotch carboniferous rocks; but the actual crater, I believe, has not been observed. That

explanation, at all events, satisfies me. The absence of stigmaria in the Swiss coal field is explained by the fact that the beds are of different age. They are of Tertiary age—at least those to which I refer. I believe there are some beds of carboniferous age in Switzerland, but the brown coals are not of that age, and the conditions of their accumulation were probably very different.

After the close of the proceedings in the Mineralogical Museum, the members spent a little time in examining the collections in the Geological Museum.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XIX. SESSION 1886-7.

The ORDINARY MEETING of the Members was held on Tuesday, March 1st, 1887, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

In the unavoidable absence of the President (Professor BOYD DAWKINS), Mr. GEORGE WILD, one of the Vice-Presidents, was voted to the Chair.

NEW MEMBERS.

The following gentlemen were balloted for, and duly elected, Ordinary Members of the Society:—

SAMUEL SYDNEY PLATT, M.I.C.E., Borough Surveyor, Rochdale.

CHARLES CHANDLEY, Hulton Collieries, near Bolton.

J. STANLEY JAMES, Surveyor, Atherton Collieries.

RICHARD WALKDEN, Colliery Manager, Darwen.

THE PRE-ATLANTIC LAND.

The first business on the agenda paper was the discussion of the paper, read at a former meeting of the Society by Mr. R. T. Burnett, on "The question of the pre-Atlantic Land," but in the absence of the author, from whom the Hon. Secretary (Mr. Stirrup) had received a note stating that he was unfortunately prevented from being present, the discussion was not proceeded with.

ON THE SUBSIDENCES IN THE SALT DISTRICTS OF CHESHIRE: THEIR HISTORY AND CAUSE.

By Mr. Thomas Ward.

Attention has been called very frequently of late by paragraphs in the newspapers to subsidences occurring in the salt districts of Cheshire, and more especially in the neighbourhood of Northwich. I wish in this paper to explain fully the nature and extent of these subsidences, as well as their cause, and the consequences following from them. The question is one of great importance and interest, not only to the inhabitants of the district where the sinkings occur, but also to geologists and scientific men. The subsidences occurring in the Cheshire salt districts may be divided into two distinct classes:—

First: Those taking the form of *a funnel-shaped hole of varying diameter and depth.*

Second: Those forming *trough-shaped hollows, varying in breadth and depth.* Synclinals, these may be called.

The funnel-shaped holes* usually differ very much in

* It should be mentioned that the holes at their first formation are not *funnel* shaped, but *well* shaped. The sides slipping till they form an angle of rest produce the funnel shape.

size. The larger class—varying from 30 or 40 yards to over 100 yards in diameter, and from a few feet to 40 feet or 50 feet in depth—are directly connected in the neighbourhood of Northwich with old rock salt mines. There are, however, in the Winsford district holes connected with the next class which are as large as, and in the case of Marton hole larger than, these connected with rock salt mines. The origin of these latter shall be explained later on.

The smaller class of funnel-shaped holes rarely exceed 15 to 20 feet in diameter, with a depth of from 10 to 20 feet. It is this latter class that causes the subsidences about which we hear so much in the papers. They are not in any way connected with rock salt mines, but occur over what are called brine "runs." In both cases it is evident that the subsiding earths must fall into some existing cavity below them, and the cause of the cavity must be the cause of the subsidence.

The trough-shaped hollows may be divided into three classes :—

1. Deep troughs with stepped or terraced sides, the whole surface being much broken up.

2. Shallower troughs, with sides not terraced or broken up.

3. Very shallow, almost imperceptible, hollows, extending over a considerable area.

Before pointing out the cause of these different sinkings, I will give the history of the various kinds of subsidence in Cheshire.

The Cheshire meres are supposed by many geologists to be the earliest instances of subsidence in the county. They may have been so formed, but the evidence to substantiate the theory is based on the phenomena attending the later subsidences. I know of nothing definitely proving the truth of the theory.

In 1533 Leland reports a sinking as having occurred near Combermere, and a pit having formed containing salt water. The pit remained for a number of years, but no trace of it now exists. This was a small sinking, being "a pease of a hill having trees on hit," and was similar to a number that have occurred in the Winsford district of late years.

In 1657 a small sinking occurred at Bickley, near Malpas. No trace of it now remains.

In 1713 a sinking occurred at Weaver Hall, to the south of Winsford. This was very small, and was at once filled in. No trace of it now exists.

From the descriptions handed down to us, these sinkings belonged to the class of funnel-shaped holes of small diameter and depth.

In the year 1670 rock salt was discovered on the Marbury Estate, about one mile to the north of Northwich. We have no records of the time when the first mine was sunk; but as there were no means of conveying the rock salt away in considerable quantities, it is probable that only one or two mines were worked in the 17th century. Early in the 18th century an Act of Parliament was obtained for making the river Weaver navigable. This was in 1721. Although the Weaver was not completed as a navigable stream till ten years afterwards, small boats conveyed parcels of salt down it at an earlier date. In 1732 some 9,000 tons of rock salt were sent down the river. In 1744 this had reached 11,744 tons; in 1747, 13,310 tons; in 1764, 30,000 tons; in 1778, 54,000 tons; in 1796, 73,328 tons. It will be seen that there was a gradual increase of rock salt shipments. The rock salt discovered in 1670 forms the first bed, lying from 40 to 50 yards below the surface, and having an average thickness of about 25 yards. All the mines were worked in this bed until after 1781, when a lower bed of

better quality was discovered. No mines were worked at Winsford in the first bed of rock salt. The first subsidences noticed near Northwich commenced about 1750. There is one mentioned as having occurred in 1720, but this date is very doubtful. In 1750 we commence with a series of subsidences of the deep and wide funnel-shaped form. I have evidence of sinkings of this kind in 1750, 1757, 1759, 1764, 1765, 1773, 1783 (three or four), 1785, all along the banks of the Weaver and the Witton Brook. Besides these, between 1760 and 1800 there were some six or more in Dunkirk and Wincham, in the immediate neighbourhood of Northwich, and since 1800 some seven in Dunkirk and several in Wincham. All these subsidences were directly connected with mines in the top bed of rock salt, and were in almost every case caused by the breaking in of fresh water. With one exception every "top rock" salt mine has collapsed and formed what is called a "rock pit hole." During the greater portion of the 18th century no subsidences other than the deep and wide funnel-shaped connected with rock salt mines occurred.

About the year 1790, when we have a distinct record, but probably a few years earlier, subsidences of the trough-shaped hollow kind commenced. As these occur very frequently where no mines have been worked, it will be seen that, unlike the former, they cannot be connected with rock salt mining. From the year 1790 to the present time this class of sinkings has gone on increasing in extent year by year. We have clear and distinct evidence from maps and documents of 1790, 1795, 1797, 1800, 1811, 1819, 1829, 1837, 1842, 1848, 1857, 1875, 1880-86 of the growth of these subsidences in the Northwich district. In the Winsford district we have little or no evidence prior to 1820. From that date down to the present time every year has seen an extension of the trough-shaped hollows. It will be

evident that the bottom of the trough must become a receptacle of the rain-fall and drainage of the immediate neighbourhood, and thus small lakes be formed. Where these sinkings occur in the vicinity of rivers and brooks they are soon detected, as the water from the streams covers the low-lying land on their banks, and a lake commences which increases year by year. At Northwich a lake of over 100 acres in extent, which is daily increasing, has been formed, besides two others within 15 years, covering over 15 acres. At Winsford two lakes, called the Upper and Lower Flashes, covering at least 100 acres, and still rapidly extending, besides several minor ones, form prominent objects in the landscape. At Billinge Green, near Northwich, a lake is now rapidly forming, which is at least two miles from any salt works. At Marton, near Winsford, a deep lake of four acres in extent has been formed since 1870. Besides the lakes thus formed, many hundreds of acres of land, comprising portions of the towns of Northwich and Winsford and the adjacent fields, are affected by these subsidences.

There has been carried on in Cheshire from the times of the Romans the manufacture of white salt from brine. As long as the means of communication were imperfect, very little salt was made, except such as was required in the county and adjacent districts. There is good evidence to show that this was probably not more than 30,000 tons per annum, all manufactured from natural springs of brine that had been known for ages. After the river Weaver was made navigable, an export salt trade commenced, which, as the following table will show, grew remarkably fast, especially at certain periods. During the last century, and in fact till 1840, the salt sent down the river Weaver fairly represented all salt exported. To this might be added the quantity consumed inland, to give the total manufacture.

After 1840 railways took off much salt, and we may safely add from a quarter to one-third more to the figures given below to arrive at the total make.

WHITE SALT SHIPPED DOWN THE WEAVER.

Year.	Tons.
1732	5,202
1744	8,279
1764	18,637
1777	31,000
1796	100,155
1820	186,666
1830	312,012
1840	414,156
1850	607,395
1860	695,772
1870	901,158
1880	1,087,214

It will at once be seen that up to the end of the last century very little salt was sent away. Between 1777 and 1796 there was a rapid growth, and it is in this interval that we first find the subsidences of the second kind of which we are speaking occurring. The Winsford shipments at this period were only about one-third of the whole. In 1825 the duty was taken off salt, hence the marked increase shown in 1830.

From 1830 to 1840 improved means of communication were opened out, and there was again a large increase. In 1844 the East Indies were opened to English salt, hence the rapid growth shown in 1850. After 1860 the alkali manufacture sprang up rapidly, and its influence is seen in the figures of 1870.

If we now examine the facts as regards subsidence by these figures, we shall find that, in exact proportion to the increase of the quantity of salt made, so do the subsidences increase. Prior to 1777 we have no records of the class of subsidence to which we are now referring. Between 1777 and 1802 we find references to slight sinkings along the course of the Witton Brook, but at that date the two channels made in 1765 and following years existed, and the banks were high except in one small portion. In 1811 the removal of a lock drained all the water off the then subsided land. In 1819 Ormerod mentions sinking as commencing in Northwich and its suburbs. So unimportant must the sinking have been early in this century, that neither Holland, in 1808, in his "Agriculture of Cheshire," nor Lysons, in 1810, make any reference to it. In 1829 the sinking had extended along the Witton Brook, and at Anderton. In 1837 the subsiding portion of the brook, which in 1790 was 130 yards long by 90 wide, had extended to 1,230 yards by 130. The sinking occupied about 20 statute acres, irrespective of the area of the brook. In 32 years some of the land had sunk 24 feet, whilst from 1839 to 1843 portions sunk 3 feet. In 1848 Ormerod, in a paper communicated to the Geological Society, describes pretty fully the extent of the subsidence. He mentions that no sinking had occurred at the Dane Bridge. Since then it has rapidly sunk, and has been rebuilt and lifted. In Leftwich no sinking had occurred; this is now one of the worst places in the district. In 1880 the top of the brook showed a sinking area 4,370 feet in length by 1,470 feet in breadth in the widest portion. Were I to attempt to describe the area of the subsidence now, my paper would be far too long. Suffice it to say that in 1880 it was estimated that in the Northwich district over 1,200 acres of land were affected, and in Winsford district over 1,500 acres. In

Northwich district nearly 900 buildings, and in Winsford district over 400, were more or less affected, and the approximate value of this property was nearly half a million of money. At the present moment the sinking in the Northwich district is proceeding at a more rapid rate than ever. At Billinge Green there was no sinking in 1850; now there is a deep pit covering several acres, and fully 120 acres in all are subsiding, damaging the banks of a canal and the bridges of a railway. In the Winsford district, since 1820, the sinking has gone on more rapidly even than in the Northwich district.

Bearing in mind these facts, let us ask ourselves what cause there is for this commencing and ever-increasing subsidence within the last century, which did not operate before? To geologists it is evident that there must be some subterranean denudation occurring which is removing portions of the inferior beds, and allowing the superior to sink into the hollows thus formed. If this be so, how is it that the denudation, if natural, has not acted throughout all past time? and if it has so acted, how is it that the evidence of its action has only been so recently shown? Again, why should a natural cause remain quiescent for ages, then commence on a small scale, and continuously and rapidly proceed to the present formidable dimensions? Volcanic eruptions are erratic; but when a volcano is in violent action the results in the shape of lava, pumice, ashes, mud, &c., are very patent. Again, after the violent thunderstorm or tropical rain-deluge, when denudation of the earth's surface takes place on a gigantic scale, the denuded earths can be seen and traced; but where is the matter denuded in the Cheshire salt districts if it is nature that is so busily at work? No trace can be found of nature's action in this matter. If, then, the subsidences now occurring are different from those which happen when nature is left free to work

herself, we must look for some non-natural or artificial cause. If the problem were put before a geologist in this form: In the county of Chester the land over many hundreds of acres is subsiding; large lakes of considerable size and of great depth are being formed; this sinking only commenced a century since, and at first was small in extent; but, as time passed by, the area affected increased in an accelerated ratio, and at the present moment still increases very rapidly—What is the cause? I take it that he would say: Does this sinking spread over a considerable area, and is it a very slow and gradual one, extending equally to all parts of the area? If so, the district may be undergoing one of those periods of depression so common to all geologic times and all parts of the earth. The answer would be that the sinking did affect considerable areas, but was not slow nor yet equally distributed over the whole area, but very sudden and rapid in parts—not so rapid in other parts, and in some scarcely perceptible; that the lines of sinking altered their direction very frequently; that a limited area would sink rapidly for a short time, then would cease, whilst another limited area previously stationary would commence to sink; that the form the sinking took was generally that of a trough, but sometimes of a funnel. This answer would at once tell the geologist that the subsidence could not belong to the class caused by nature working slowly during long periods of time. The next question the geologist would ask—and his questions would be based on his knowledge of subsidences occurring in various parts of the world—would be: Has any violent volcanic or earthquake action occurred removing earths and causing the subsidence? or has sudden elevation of the neighbouring land taken place causing a corresponding depression? The answer would be that nothing of the kind had occurred, or was occurring. The geologist would be puzzled. He would know that for

subsidence to take place there must have been a removal of matter by some means from the place into which the subsiding earths had fallen. He would know also that this removal of subterranean matter must have been going on for nearly a century, not regularly, but in an increasing ratio, and more rapidly than if caused naturally. The great medium for removing matter on the earth's surface, or denuding the various rocks, he would know was water, acting mechanically, for the most part; but how could water act mechanically deep down amongst the rocks? The solvent powers of water he would know, and the existence of water escaping from below, and running into streams or rivers, bearing with it the matter it had dissolved, he would also know. He might think, would mineral springs cause this rapid denudation? An examination of authorities on these springs would tell him that mineral springs rarely contain much dissolved matter, and seldom run away so copiously as to cause subsidence over the face of the rocks that they dissolve; in fact, that their action is scarcely perceptible in the course of ages. He would learn, however, that water passing over salt rocks carried away a large amount of salt in solution, salt rock being the most soluble of all the large rock masses. Having gained this knowledge he would enquire the nature of the rocks in the subsiding area, and would be told salt. Now he has a clue; but he wants to know whether there are any salt springs running away to waste in the brooks and rivers so copiously as to cause the subsidence. In asking this question, he would do so with great diffidence, for he had already learned that mineral springs, whatever their contents, never run away so copiously, carrying large quantities of dissolved matter with them as to cause appreciable subsidence in a lifetime. He would also think that if these springs existed at all, they must have existed for ages, and have been working conti-

nuously carrying away salt; and if so, the subsidence must have been going on continuously for ages; but the main element in the problem he is asked to solve is, that the subsidences are, geologically speaking, only of the present moment—their late commencement and rapid growth capable of being clearly traced. He would find that in the subsiding area no such springs are known to exist at the present day, but that previously to the subsidences there had been a few which ran into the streams, but that they were only small, and that no subsidences had ever been heard of in connection with them during their known history of over 1,500 years.

Completely puzzled to account naturally for the phenomena, we will suppose our geologist to go to the spot to investigate the subsidences for himself. On examining the sinking area and the banks of the streams, to try to detect springs, he finds every evidence of rapid and destructive subsidence, but no escaping natural springs. He finds, however, that, scattered over the sinking area, there are a large number of wells, out of which is being pumped enormous quantities of water containing salt. He finds this water taken to manufactories and there deprived of its salt, which salt, to the extent of thousands of tons every week, is sent out of the district. He cries "*Eureka.*" He at once decides that the numerous artificial springs, containing more salt rock in solution than any natural spring ever contains, must be the cause of the rapid denudation of the salt rock, and the consequent subsiding of the upper earths. He would then ask how long these artificial springs had been working, and whether they had increased during the present century. The facts, as exemplified in the table of shipments of salt down the Weaver, would furnish him with all the information he wanted, and, comparing the table with the results, he would

see that there must be a connection, or else a marvellous coincidence. We will now examine the matter, and see how the connection thus traced is really brought about.

To thoroughly understand the matter, it is necessary to bear in mind what I mentioned in my paper on rock salt,* read before you last year, viz., that the beds of rock salt in Cheshire occupy the lowest parts of an old salt lake, lying, as it were, at the bottom of a basin. If these beds were denuded of all the overlying clays and earths, and water allowed to run into the space thus denuded, the basin would become full of water, and would soon run over at the lowest point. The moment the water reached the salt bed, it would commence to dissolve it, or feed upon it, until the water in immediate proximity to the rock salt became saturated, or could take up no more salt. This would be the case when 100 parts of water took up about 36 parts of salt, making in the mixture of 136 parts of salty water or brine about 26½ per cent. of salt. Roughly speaking, the mixture would be three parts water one part salt. The specific gravity of the brine would be 1·2, and being heavier than water, the brine would remain at the bottom, on the salt, and only slowly diffuse through the overlying water, except forced to mix by being agitated and caused to move over the salt. In the case we are supposing, the water filling up the basin would agitate and disturb the brine lying on the salt less and less, as the basin filled up and the water became deeper, so that, the deeper the basin, the less salty the water that finally ran over the lowest portion of the rim would be. This escaping water would be a natural salt spring, and it is clear that unless the salt lay very near to the rim, that is, unless the basin were very shallow, the spring would only be slightly salty, and not fully saturated.

* "On Rock Salt," by Thos. Ward, read before the Manchester Geological Society, January 26th, 1886.

Let us now suppose the basin to become filled with earths like those overlying the salt in Cheshire, the problem in principle is still the same, but complicated in details. Instead of one spring running away, there would be a number reaching the surface at the lowest portions or weakest portions of the overlying earths, almost invariably along the sides of brooks and rivers. The rainfall, minus evaporation, and minus also the quantity draining off the surface, and flowing in streams, would give the quantity escaping in springs. In Cheshire, owing to the conformation of the surface, and to the salt being in many places covered with impermeable marls, no great quantity of water could at any time escape in springs, and owing to the depth at which the salt lies, none of the springs would ever be fully saturated. History proves this, for all the reports of salt springs mention them as either barely reaching the surface, or as gently oozing over, and running into the neighbouring streams. The known natural springs also were but few, as is indicated by the salt towns or "wiches" founded to utilise these springs. I have proved these points in other papers, so will pass on. Having shown that naturally salt springs are neither copious nor fully saturated, it is necessary to ascertain what effect they would have upon the surface of the rock salt. Reverting to our first illustration, which is a true one for Cheshire, we see that the first water reaching the salt would become saturated, and being heavier than fresh water, would lie at the bottom, and its salt would only become slightly diffused, unless considerable motion took place. As the spring would be the overflow of the top waters, unless something abnormal happened, no violent motion of the bottom water would occur so as to cause a current in one particular line. The action of the water would be practically equal over all portions of the salt bed subjected to it, and the salt denuded or dissolved and flow-

ing away would be the produce of a large area, and the surface waste of the salt bed would be very small, so small indeed as to be inappreciable in a lifetime. Doubtless, in the course of ages, the bed of salt would be appreciably wasted, and thus the meres might be formed. So far I have dealt with the action of water on beds of salt lying below the surface of the earth, and, I think, it will be seen that as long as nature worked in her customary way, subsidence of land wonld be inappreciable in historic times. Facts substantiate this all over the world, for wherever salt lies, as I have described, and brine springs escape into the streams, no subsidence ever has been noticed, and no record of such, as far as I have examined, is to be found.

Our way is now clear, we have seen that the subsidences now occurring cannot possibly be caused naturally. We will now examine what is being done by man, and see if the phenomena exhibited follow naturally from such action.

The first brine springs flowing to waste in streams were utilised in Cheshire by the Britons and Romans, and their successors, and furnished, as far as can be learnt, all the salt needed. For many centuries, the population being small, and the means of internal communication bad, there was no increase in the make, and down to the sixteenth and seventeenth centuries the brine was lifted out of the wells by means of buckets, and filled into troughs, which conveyed it to the very small leaden pans then used. When the manufacture increased, hand pumps were used, and wells were dug along the banks of the rivers, brine being found at a very short distance from the surface. As the number of wells increased, the brine decreased, and windmills were used to lift it to the surface, and the shafts were sunk deeper. Steam engines succeeded windmills, and the brine had to be sought for deeper and deeper down, until, of late years, it is necessary to sink down to the salt itself to get

brine, and frequently, at the end of a busy season, the brine is extremely scarce, and fails entirely in some wells or shafts. From this rapid *resumè* of what has been done by pumping brine, it may clearly be seen that first, the escaping springs were used; then, that the reservoir of brine contained in the basin, was pumped down gradually, the increasing number of pumps or artificial springs causing an increased motion of the body of brine, and so causing more dissolution of salt. Finally, the basin became nearly exhausted of the accumulated supply of ages, and the artificial springs had to depend upon the water derived from the rainfall, which, reaching the salt, and running over the surface, saturated itself as it moved along.

As long as the brine was high in the reservoir, little action would take place upon the face of the salt, but that as the pumping increased and the brine diminished, so would the action upon the salt increase. We saw that as long as the water remained quiescent on the salt, little waste or denudation occurred. At the present time we have a constant succession of particles of water, each taking up salt as it moves along, until it is saturated. Each artificial spring or pump causes a flow towards itself of saturated or saturating particles, and as this flow follows the line of least resistance, the face of the rock salt becomes channelled by the dissolution of the salt by the unsaturated particles of water. This is not a case of mechanical denudation, but waste caused by solution. As soon as a particle is saturated it ceases to act upon the salt, and passes over it without causing further denudation. It will be seen, then, that at the point where the water first comes into contact with the salt, rapid solution occurs, which diminishes as the particle approaches the pumping station.

We are now able to state certain necessary consequences resulting from the pumping of brine in the Cheshire salt

basin. The accumulated store of brine having been pumped down—all being obtained now must be made as it were from hand to mouth. The fresh water on its course to one or other of the numerous pumping centres, flows over the salt bed at first in no regular channels, but after a time in defined courses, making itself channels exactly as the rain-fall on the surface of the earth makes first tiny streams, then rivulets, brooks, and rivers. The underground streams of brine are broken up by the great number of pumping centres, but their channels continually widen and deepen. Where the overlying earths are not too tenacious, they soon follow the hollow, or trough formed on the surface of the salt bed, and we have a corresponding hollow or trough formed on the surface of the ground. Where this hollow forms at an early stage, it rarely becomes a very deep one, for the sinking earths impede the course of the flowing brine stream, and cause it to spread over a wider surface. These subsidences are the shallow troughs, not stepped or terraced on the sides, and show best in streets and roads, where the weight of the houses and the constant passage of traffic seem to cause the earths to gradually follow the wasting surface of the salt. Where, at a considerable distance from the shafts, the water has not got into a definite channel, it spreads itself over a wide area, and the denudation is more generally spread, and a very extensive shallow trough or basin is formed. Again, where the pumping stations are near to each other, or in nearly the same line, the various rivulets and streams of brine merge into one broad and deep channel, in which the denudation proceeds very rapidly. The depth and width of this channel cause the overlying earths to subside rapidly, forming deep troughs, with stepped or terraced sides, where the earths have broken or slipped away in huge masses. The "flashes" at Winsford,

and some of the later sinkings at Dunkirk, Northwich, show this form of deep trough with stepped sides. Some of these huge troughs are from a quarter to half a mile across, and from 30 to 40 feet, or more, deep, and when they occur in the line of a brook or river, lakes of great depths form. Where the earths are very tenacious (consisting of strong marls and a kind of flagstone), they remain suspended for a considerable time over these deeper troughs, and when they will bear no longer, a sudden fall occurs in one spot, and tens of thousands of tons of the suspended earths fall into the cavity below, forcing the stream of brine out at any weak place in the immediate neighbourhood, generally near brooks, and leaving a huge crater-shaped hole, which fills with water. These holes show themselves more particularly in the line of brine flow from Marton Hole to the Winsford salt works. Where, on the contrary, the earths have little tenacity, and the brine stream is not so large, a number of less subsidences occur, leaving the small funnel-shaped holes of 15 to 20 feet in diameter. It is these latter that occur in the town and immediate neighbourhood of Northwich, and cause so much alarm, and which are exaggerated in the reports of the newspapers. A great number of these holes have fallen in of late years in a comparatively small district, viz., the lower portions of Castle Northwich and Winnington, near the river Weaver, and in Leftwich, near the Weaver and the Dane. The sands in this district are very thick, leaving a comparatively thin layer of marl over the rock salt. As the surface of the salt is eaten away by the brine stream proceeding towards Winnington and Anderton, there is a general gradual subsidence of the shallow trough kind. Of late years, however, more brine has been pumped in the Winnington district, and there has been a tendency towards the deep and wide trough formation of subsidence, and slips

or steps show themselves in the Castle district. As the earths have not sufficient tenacity to remain suspended long enough for a huge cavity to be formed like those between Marton and Winsford, it is almost certain that there will be a continuous series of subsidences of a small kind within the area above mentioned, and gradually extending further into Castle and Leftwich. In these smaller and shallower subsidences, which are exceedingly destructive to property, standing upon the subsiding surface, but not so dangerous as the larger and deeper ones would be, we may see frequent changes in direction. A rapid sinking of the earths dams the channel and stops the brine at one spot, but it soon finds another channel at a short distance off; and the property standing over this new channel, which had previously been unaffected, now commences to sink, whilst the old sinking property has a temporary respite.

So far no mention has been made of sinkings which arise from a combination of the two causes which have been mentioned, viz., subsidences connected with the mining of rock salt and those connected with the pumping of brine. In the immediate neighbourhood of Northwich, as has been pointed out, great numbers of old mines have fallen in, and the district has many old shafts. Of recent years the mines in the second bed of salt, when worked out or "got" up to the boundary, have been allowed to fill with brine or water, which soon becomes brine. Out of these old abandoned mines—now huge brine reservoirs—a great deal of the brine used in the Northwich district is pumped. This pumping causes a flow of brine on the surface of the first bed of rock salt towards the shafts of the various mines, and as these are in the district where the old top rock salt mines were worked, deep channels running towards the old shafts are formed, and as the fresh water eats away the salt near the shafts, very rapid and destructive sinking occurs,

forming deep broken troughs in the line leading to the shafts. Not only do the sides of these troughs become stepped or terraced, but at the bottom of the trough, before it becomes filled with water, the turf covering the earths is forced up into rolls of a considerable size, showing how pressure can double up and contort earths. These rolls are a good instance of what pressure can do on a large scale with earths that will yield, and may perhaps afford a hint as to how some of the contorted strata occurring so frequently in various districts have been caused. When the subsidence occurs in a district where old mines exist, it is of a more destructive kind than any other, for when once the upper surface of salt is eaten so deep as to open up a way into the old mines, the overlying earths slip into the cavity, and the whole area above the mines becomes broken up and full of huge crevices and steps. No sooner does the water of the brooks and streams cover such a broken locality—and as all the mines were near streams this occurs very quickly—than a body of water rushes down until, by making a puddle of the underlying clays and marls, it stops itself. As the denudation of the rock salt continues after the puddling, a cavity is again formed, and the puddle gives way, allowing water down once more. This alternate inrushing of water and puddling of the clays goes on constantly, for the pumping of the brine removes the water after it has saturated itself, and the water being removed, the puddle slips and lets fresh water in. It will be at once perceived that where large bodies of fresh water come into contact time after time with the rock salt in a very limited area, the amount of solution of salt must be much greater than where the ordinary rainfall gently percolates through the overlying earths, and spreads over a large area. This violent destruction of salt, and consequent break up and subsidence of overlying earths, is seen to perfection at Marton and

Dunkirk, in the neighbourhood of Northwich, where within the last 10 years or so land and roads have sunk fully 40 feet, and green fields in Marton 10 years ago, and in Dunkirk 5 years ago, are now 15, 20, and 30 feet under water. It is not my intention in this paper to enter into the question as to the amount of property injured or destroyed by the brine-pumping subsidences. I can only point out that as the limits of the beds of salt are not known, and as water reaches the salt beds from all directions, and traverses them to the pumping centres, it necessarily follows that subsidence may and does occur in various portions of the salt area. In the Cheshire salt district, and especially in the Northwich portion of it, there are a very large number of property owners having houses and lands over the salt beds who are in no way connected with the pumping of brine; and these owners suffer not only the loss of their rock salt by the pumping of brine, but also damage to their houses or other property on the surface of the land above the sinking area. For this damage and loss there is no remedy in law, because it is impossible to tell which of the many brine pumpers scattered over the large salt area is occasioning any particular injury. This being so, it is evident that a great injustice and wrong is being done to such property owners.

I look on these subsidences as being of the greatest interest to geologists and scientific men; they compress into a few weeks or months nature's work of untold generations, and we have here an instance of the working of natural laws, that is, the solution of rocks of salt by water on a scale immensely larger than can be found anywhere else. Nature, unaided by man, requires geologic ages to produce the gigantic effects which by man's interposition are being produced year by year in the salt districts of Cheshire.

Mr. STIRRUP said: The subsidences which Mr. Ward has described in his very important paper affect, as he has told us, a large amount of property in Cheshire. Some years ago the question engaged the attention of the courts of law, but the case was lost because evidence was given that the whole of the sinking which was observed in Northwich and the vicinity was due to the operation of natural forces, and had been going on for ages. But I think, after the evidence and the statistics Mr. Ward has brought before us to-day, it can scarcely be doubted that nature's operations have been very much accelerated by the interposition of man; and that, if salt works had not been established in that neighbourhood, we should not have had the enormous subsidences which now take place. It seems to me that, according to the amount of brine which is pumped out, so in proportion does the sinking of the land go on; and such, I suppose, will be the case till these salt beds have been practically worked out. The great production of salt for the alkali manufacture is, I take it, one great cause of the numerous subsidences which are taking place throughout the district. With regard to the effect of water upon the salt beds, Mr. Ward has shown us that, in a natural way, that effect would be but slight; it is only when the water is put in motion—as it is by the continual pumping—that the rock salt is dissolved rapidly. In the Middlesborough district that is the plan they are adopting to get at the salt beds. They do not raise the rock salt, but force water down to the salt beds, where it is converted into brine and then pumped up. I am not acquainted with the district, but no doubt Mr. Ward knows all about it, and he can tell us whether the intervening beds are of such thickness as to be likely to resist any tendency to subside. I think the Society is deeply indebted to Mr. Ward for bringing so forcibly before us the action of water upon the rock salt beds of Cheshire.

Mr. NEWTON: I do not know much about this district, but I know sufficient to be able to corroborate what Mr. Ward has said about the exaggerated reports of the subsidences by the press. For instance, in one that occurred a few months ago, I saw it recorded that the floor of a stable went in, and that two horses disappeared, and the stable boy saved himself by sticking hold of the tail of a third horse! I believe that was said to have occurred in the district of Leftwich.

Mr. WARD: No, Witton.

Mr. NEWTON: May I ask Mr. Ward if he will give an explanation of those Leftwich subsidences? The reason I ask is because I have a theory of my own, and I should like to hear if it is the right one. In the Billinge Green district there must be a great thickness of superincumbent earth over the beds of rock salt, and also a great distance from the nearest brine pit. I suppose the shaft at Dunkirk will be as near as any, and that is a great distance. So with Marton; there are no brine pits in the neighbourhood of Marton Hall. That great subsidence which took place 15 or 16 years ago there, occurred all in one night. A large hole, 100 feet deep, was formed, at a great distance from any brine pit. I should like to hear from Mr. Ward what he thinks of those subsidences—whether they were "trough or funnel-shaped" subsidences.

The CHAIRMAN: I remember going into the district of Northwich some years ago to see an old beer house, near the river side, which was gradually sinking. I went, with some friends, once a year, for the purpose of angling in the stream, and the third or fourth visit we could angle in the pig-sty! By the side of a small stream, between Acton Bridge and Northwich, which had embankments on either side 10 feet high, there was a very pretty section of the

strata—three or four distinct beds—containing nuts, leaves, and other vegetable remains, quite carbonised. The bed of the stream was running over one bed, ploughing it out; another was a foot higher, with a foot of marly sediment between it and another six-inch black patch, then another foot, and six inches again, four feet from the surface. It struck me at once that that must have been gradually subsiding for a long time back; and these washings—for such they must have been, because the beds lay prostrate—these washings in of strata, containing vegetable matter, must have taken place at different periods, after which came a rest, and the brook began to scoop out the deposits, leaving a beautiful section in the embankment. But I fancy that has all gone down now, through recent subsidences of the ground.

Mr. STIRRUP: These deposits had taken place before this large sinking commenced?

The CHAIRMAN: Yes, that was my idea.

Mr. STIRRUP: I should like to ask whether the water found in those funnel-shaped and other holes is salt or not?

Mr. WARD, in replying to the various questions addressed to him, said: The first question asked was about the thickness of the salt beds. The upper bed is about 25 yards thick, but it varies. It tapers off on one side to 12 or 13 yards; there are other portions, again, 28 yards; but you may take the average to be about 25 yards, in the Northwich district, of the first bed of rock salt. The surface of the bed is rather undulating, having evidently been exposed to the action of water before it was covered over. It is separated from the second rock-head by 30 feet of hard marl and compressed clay. This is very hard, indeed; and underneath that we have a bed of rock salt, which is about 36 yards thick. It is in that bottom bed that mines are worked

now for rock salt. Very few of the bottom mines have fallen in—some have done so, and have left destructive appearances on the surface—it is the top mines, nearly always, that give way. The bottom ones frequently got filled with water. I was not speaking of the thickness of the beds as being unknown, but their area. We cannot tell, without boring, how far they extend; the only means of knowing is to see where the ground sinks, because you may take it wherever it sinks there is salt underneath. When borings have been made at some distance outside, salt has not been met with; therefore, I do not think the beds are of very great extent—they do not extend for miles, like some coal seams that you meet with. The salt beds generally lie in isolated patches. The question as to Middlesborough is a very important one for the Middlesborough people. They have, fortunately for them, a great thickness of sandstone—with layers of marl, however—above the rock salt, and this may keep them safe for some considerable time; but they have their difficulties already. At first they put water down, but now there is sufficient in the sandstone to supply all that is necessary. The fresh water is most destructive to the rock salt at the bottom of the bore-holes; it eats it away, and a kind of balloon-shaped hollow is formed, causing, in course of time, the earth immediately about to fall in. Already four or five of these bore-holes have collapsed. The salt bed there is 100 feet thick. When the workings become extensive the difficulties will be greater still; the sandstone will hold out for a certain time, and then go down suddenly. As regards Leftwich, up to recent years Leftwich did not sink, although the salt manufacture was carried on there; but since Brunner, Mond & Co. have been making alkali so extensively, and consuming 100,000 tons of salt per year, the sinking along the Leftwich line and in the town of Northwich has extended day by day. During the last five

or six years the roads in Leftwich have been falling in constantly, so that, for a distance of 50 or 60 yards, we had to put huge balks of timber alongside the road, and then planks, carrying the road over all. So far, we have been preserved from any serious mishap, but outside these balks, holes have appeared, and they keep working further up into Leftwich. I know there is a theory about sand there. There is a great thickness of sand at Leftwich; this bed of sand is below the river, and the river bed itself sometimes falls in. My theory—which accords with all the known facts—is this: Owing to the great depth of sand the thickness of the marl below it is reduced—that is, between the sand and the rock salt—consequently the marl has not the same strength, and cannot bear so long as if the whole body was marl from top to bottom; and when the water has eaten away the rock salt, instead of the marl holding up for a long period and a big hole going in, as at Marton, a small hole goes in, and water rushing down, the hole gets choked. Then sinking goes on again till another portion gets eaten away, and another hole goes down. Within a period of three or four years 20 or 30 such holes have been formed in the neighbourhood of the bridge at Northwich, and near the River Dane at Leftwich. Only last Wednesday a serious one went in, at a place where before there had been repeated subsidences. The sinking at Leftwich, then, is due to the bed of marl being thinner, and consequently less able to hold out for any considerable time. Billinge Green, where, as before stated, there has been a considerable sinking, lies between the three great pumping centres of Middlewich, Winsford, and Northwich; and it is difficult to say to which of those pumping centres the mischief is to be attributed. I think it is possible that all three are doing it. The lines of subsidence, as indicated by holes, seem to bear out this impression. In the neighbourhood of Marton we find a series of

holes differing from those in the Northwich district. The marl there is thicker, and the rock salt lies deeper; consequently a longer time must intervene between the scooping out of these huge holes in the rock salt and the falling in of the earth. When the fall takes place there is a great cavity. In one, six years ago, no less than 70,000 tons of earth must have gone below in one single drop, leaving a huge funnel-shaped hole. This great body of earth falling in drove out what brine there was, and forced it up to the surface, so that two or three pit holes were formed on the surface of the ground—on the weak portions of the land—and out of these brine ran for several days. Between Marton and the Winsford works you can trace the whole line of sinking, and also see the land breaking up in the usual fashion. The hole at Marton now covers nearly four acres, and it goes almost straight down. The water in these large holes is fresh, or spring water—just the ordinary fresh water that would drain off the surface into a large hollow of that kind. In none is the water salt, unless they are holes into which salt has drained from the brine pipes. The district is a very interesting one, more especially to a person who, like myself, has occasion to traverse it day by day, and can note the changes of level as they occur.

Mr. WARD showed upon one of the maps the extent of the lake which has been formed by repeated subsidences at Witton. This lake, he said, was constantly extending in area. Land which three years ago yielded crops of hay was now from 15 to 30 feet under water.

Mr. STIRRUP: May I ask if any attempt has been made to trace the course of these underground streams by staining the water with aniline, or other means?

Mr. WARD: Such a test has often been spoken of. On one occasion I believe sawdust was put down in one shaft in

the neighbourhood, and was pumped up at a shaft
away. You will see the difficulty that arises, fr
ordinary method of tracing, is this: That the water
it first reaches the rock salt, eats it away rapidly, bu
gets nearer the pumping shaft, the rock salt is
affected, from the fact of the water being already sat
It will be seen that some of the soundest parts of th
are those nearest the shafts. A man may actually
shaft on his own property and suffer no injury, but
same time be injuring his neighbours over a consi
area.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XIX. SESSION 1886-7.

The ORDINARY MEETING of the Members was held on Tuesday, April 5th, 1887, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

Mr. JOSEPH DICKINSON, F.G.S., Vice-President, in the Chair.

NEW MEMBER.

The following gentleman was balloted for and unanimously elected an Ordinary Member of the Society:—

Mr. FREDERICK W. SCOTT, Atlas Works, Reddish, near Stockport

The following are the recent additions to the Library:—

Chesterfield and Derbyshire Institute of Engineers: Transactions, Part 4, Vol. XIII.; Contents and Index; Part 5, Vol. XV.—*From the Institute.*

Edinburgh Geological Society: Transactions, Part 2, Vol. V.—*From the Society.*

Essex Field Club: Transactions, Part 2, Vol. IV.—*From the Club.*

Essex Naturalist, Nos. 1 and 2.—*From the Essex Field Club.*

Hertfordshire Natural History Society and Field Club: Transaction Part 4, Vol. IV.—*From the Society.*

Leeds Geological Association: Transactions, Part 2, 1885-6.—*From t Association.*

Liverpool—Geological Association: Transactions, Vol. VI., 1885-6.- *From the Association.*

——— Free Public Library, Museum, and Art Gallery: 34th Annu Report.

London—Royal Society: Proceedings, No. 250, Vol. XLI.; Nos. 25 252, Vol. XLII.—*From the Society.*

——— Iron and Steel Institute: Journal, No. 2, 1886.—*From t Institute.*

Manchester Association of Engineers: 31st Annual Report of Counc 1886; President's Address—Chief Mechanical Inventors of Lanc shire (Pamphlet).—*From the Association.*

Midland Institute of Mining Engineers: Transactions, Part 85, Vol. X.- *From the Institute.*

Mining Institute of Scotland: Transactions, Part 8, Vol. VIII.—*From t Institute.*

North of England Institute of Mining and Mechanical Engineer Transactions, Part 1, Vol. XXXVI.—*From the Institute.*

South Wales Institute of Engineers: Proceedings, No. 2, Vol. XV.- *From the Institute.*

Canada—Geological and Natural History Survey of Canada: Annu Report, Vol. I., 1885. Maps to accompany the same.—*Fr Director of Survey.*

——— Hamilton Association: Journal and Proceedings, Vol. I 1885-6.—*From the Association.*

U.S.A., Cambridge; Harvard College: Museum of Comparative Zoolog Bulletin No. 2, Vol. XIII.—*From A. Agassiz.*

——— Philadelphia: Academy of Natural Sciences: Proceedings, Part 1886.—*From the Academy.*

——— Philadelphia: Journal of Franklin Institute, Nos. 734-7 Vol. CXXIII.—*From the Institute.*

——— Washington: U.S. Geological Survey, Bulletin Nos. 30-33. *From the Government.*

Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft, Heft Band XXXVIII.—*From the Society.*

Brussels: Société Royale Malacologique, Procès-Verbal, August December 4, 1886.—*From the Society.*

Dresden: Naturwissenschaftliche Gesellschaft, "Isis" in Dresden. Ju to December, 1886.—*From the Society.*

Paris: Revue de la Législation des Mines. November-December, 1886.—*Purchased.*

Pisa: Atti della Societa Toscana di Scienze Naturali: Memorie, Vol. VIII., Fasc 1. Processi-Verbali, Vol. V., November, 1886, January, 1887.—*From the Society.*

Roma: Atti della Reale Accademia dei Lincei; Rendiconti, Fasc 1-4, Vol. III.—*From the Academy.*

St. Petersburg: Bulletin du Comité Géologique, Nos. 9-11, 1886, No. 1, Vol. VI., 1887.—*From Department of Mines.*

——— Académie Impériale des Sciences: Memoires, Nos. 7-11, Tome XXXIV.; Bulletin No. 3, Tome XXXI.—*From the Academy.*

Sydney—Royal Society of New South Wales: Journal and Proceedings, 1885, Vol. XIX.—*From the Society.*

DISCUSSION ON MR. G. H. KINAHAN'S PAPER ON MARSH (NATURAL) GAS.

The CHAIRMAN said he should be glad to hear any remarks which might be made on the subject of Mr. Kinahan's paper, which was read at a previous meeting. (Part V., Vol. XIX., p. 121.) Mr. Kinahan pointed out that the fire-damp which came from carboniferous seams was not utilised in this country so much as it is in America. He (the Chairman) did not know of any place at present where natural gas was utilised; but he had known it to be utilised in different parts of the country for lighting up pit bottoms and also for lighting workshops on the surface.

Mr. STIRRUP: Mr. Kinahan's idea seems to me a laudable one. Taking a great interest in American geology, and having visited the United States and Canada, he has seen the use which is there made of the natural gas which issues from many of the palæozoic rocks, and he is desirous that we in the old country should take advantage of the

experience there gained. He thinks it quite possible that we may have beneath us, in our own colliery districts, gas pounded up which might be utilised in the same way as in America, if proper attempts were made to get at it, and, as he puts it, might not this explosive gas be drawn off from coal mines and so prevented from being a source of danger? This is one of the practical points which he wishes to bring before our Society, which, he is aware, is largely composed of gentlemen interested in the colliery industry. The utilisation of natural gas in America is of quite recent date. In Pennsylvania it has already, within the last two or three years, revolutionised some of the industries to which it is applied. There is a steel works at Pittsburg, one of the largest, I believe, in the world, now using natural gas, which is brought in pipes from an area some miles outside the city; and not only there, but in many other towns throughout the States the gas is being conveyed not only into mills and workshops, but into private houses for domestic purposes, the consumers being charged at a very low rate. The illuminating power of the gas, I believe, is inferior to that of coal gas, but it has a greater heating power, and it is found extremely profitable, and superior to coal gas, for use in certain industries, such as the glass, iron, and steel manufactures. There has recently come into my hands the Preliminary Report on Petroleum and Inflammable Gas, by Prof. Ed. Orton, of the Geological Survey of Ohio. This is published at the expense of the State legislature, and is a portion of a proposed volume on the Economic Geology of the State. Professor Orton deals with the probable area of distribution of these substances and shows where borings might be made with probable success. It is, in fact, a guide for those interested in such matters. Opinions of course vary as to the area of distribution and the probable duration of these natural reservoirs. Professor

Lesley, the State geologist of Pennsylvania—a State which has benefitted so largely by the utilisation of natural gas—speaks strongly of the *temporary* character of the supply. The store, he says, is not inexhaustible; and although it may last, at the present rate of consumption, for probably 10 or 20 years, young men who are now living, he says, may see it come to an end. Of course it will be understood that petroleum and this natural gas are really one and the same; the gas is the lighter portion of the petroleum, which filters into the porous sandstone rock which serves as a reservoir; and it appears the coarser the sandstone the more it holds of this gas. It was in the sandstone rock, Berea grits, belonging to the Carboniferous series or Subcarboniferous Measures of America, where it was first found in such great abundance in Pennsylvania, and in Canada, I think, also; but it came somewhat as a surprise to the geologists in parts of the State of Ohio to find the gas emanating from a source much deeper—from another geological horizon altogether—as old, in fact, as the Lower Silurian, where the rock (the Trenton limestone) was very different both in origin and composition to the Berea grits.

There is another point of interest to which Professor Lesley draws attention—one which has embarrassed the attempts to profitably use the small issues of natural gas from our own coal seams. I refer to its inconstant character.

Professor Lesley says: "It has been an embarrassment to some consumers that there was not sufficient steadiness in the heat produced. One day the required heat was obtained at a certain pressure; the next day the same degree of heat could not be got from the same amount of gas. Chemical analyses have furnished the explanation, but only by opening up to view a most extraordinary and unforeseen

fact, viz., that the gas blown off from a well varies in its essential quality from day to day.

"Analyses of two samples of gas from the same well have exhibited the startling fact that at one time the gas is composed of only 35 or 40 per cent. of the marsh gas element, and at another time of 70 or 80 per cent., or even more."

I do not suppose it probable that we shall ever be able to tap such large resources as they have in the United States. They have a much larger area to draw from, and their rocks seem to lie more evenly—they are not so much broken up as ours; and the more broken up they are the more chance there has been of the gas escaping through fissures or faults.

The CHAIRMAN: I shall be glad if any member can give us any instance of this natural gas being utilised. According to my observation, the issues of gas in this country are not generally sufficiently large to make them worth anyone's while to utilise them. A large issue took place at Wallsend and blazed away for years, which was proposed to be taken to the Newcastle Gasworks, but it pined off before the idea was carried out. Many of the issues we have here do not exceed 20 cubic feet per minute; so that it is not worth the expense. I think the measures that were taken at the Oaks Colliery, when an immense extent of workings was shut up, yielded only some 300 or 500 cubic feet per minute.

Mr. STIRRUP: Of course the issues in America are of vastly greater extent.

The CHAIRMAN: We have sufficient to trouble us in the workings, but not sufficient to make it worth while to attempt to work them, except to a small extent.

Mr. G. PEACE said he had been informed by a gentleman who had been in Pennsylvania that the gas used at Pittsburg was given off at the rate of 200lbs. to the square inch. That was very much in advance of anything in this country.

Mr. CLIFFORD said that when he was last at Pittsburg, some three and a-half years ago, no gas wells had been sunk in the immediate neighbourhood of the city. Several were *being* sunk but none had then struck gas. Some of the wells, which have since proved good yielders, were sunk through the coal seams of the district, while others, being on low ground near the banks of the rivers, were below the outcrop of the Pittsburg seam, in strata which until recently have been regarded as below the coal measures. The gas used in the ironworks of Messrs. Chalfont, Spang, & Co., was for many years brought from distant wells in pipes. Up to 1876 he believed eight wells had been exhausted to keep up that firm's supply of gaseous fuel. As a colliery surveyor and a railway engineer he saw a great deal of what was going on in Ohio and Pennsylvania in 1872 and 1873. Gas wells were first bored for oil (with exception of those in Pittsburg), and were known as dry wells. A great number of these wells—some of them very deep—were then to be seen all over Western Pennsylvania and parts of Ohio. The yield of gas from some of them, particularly on the eastern fringe of the oil regions, was simply enormous.

The CHAIRMAN: Do you know how many cubic feet per minute the gas springs give off?

Mr. CLIFFORD mentioned an instance where, at the mouth of the well—7 inches bore—there was said to be a pressure of 1000 lbs. per square inch. The gas from this well was fired, when it sent up a column of flame 120 feet high, and burned through the whole of one winter. This well was

situate in Butler Co. Pa., near the Connequenessing river, about twelve miles from its confluence with the Beaver. The success of the Pittsburg gas borings has stimulated enterprise in other parts of the country, and many of the barren or dry wells sunk sixteen years ago and more, have recently been deepened, and have become paying gas wells, especially those in the Mahoning Valley. Pittsburg people have for a long time had an idea of utilising natural and waste gas. Many years ago one of the companies which supplied illuminating gas obtained it from coke ovens at Mc.Keesport, nineteen miles off.

HUNTER SPENCER'S WATER-TIGHT CARTRIDGE CASES.

Mr. G. H. HOLLINGWORTH, F.G.S., exhibited samples of Mr. Hunter Spencer's patent solid water-tight cartridge cases for glycerine dynamite blasting. He explained that the peculiar merit of those cases lay in their being woven before being vulcanised. Hitherto there had been a great deal of difficulty owing to leakage, and, on the Continent, so seriously had this been felt, that it had caused the water cartridge to go out of use to a great extent. He also noticed that Mr. Sawyer condemned the use of water, owing to leakage, and recommended a gelatinous substitute. Water, however, cost nothing, and it was a question of saving in price.

The CHAIRMAN: In what respect does this differ from Mr. Settle's cartridge and Sir Frederic Abel's, and Dr. Mc.Nabb's?

Mr. HOLLINGWORTH: It is made perfectly water-tight by

the special process of manufacture I have mentioned: the water-proofing is done after it is woven, the peculiarity of the fabric being that the seams are woven together, not stitched.

The CHAIRMAN: The great secret of all these water cartridges seems to be in having the cartridge perfectly isolated, in the centre, and not allowing it to lie at the bottom or against one side. In the latter state it does not seem to be safe in presence of gas. That, as I understand, is the only difference between Mr. Settle's cartridge and previous ones; he isolates it by fixing it in the centre of the water.

Mr. FLETCHER asked if it was true that the gases evolved from the gelatine dynamite cartridge, though less perceptible than the fumes of gunpowder, were really more injurious to the health of the workmen. He had been told by those who used the dynamite cartridges that they were more injurious than gunpowder.

Mr. BURROWS: I think there is no doubt about it. Those who make up the cartridges, if they do the work in a cabin below ground where there is no great current of air, complain that the mere handling of them makes them sick and causes headache. Those who have to do it with us, now, rather than do it in a room, prefer to sit in a main road and put up with the draught in order to avoid the smell. Where there is a brisk current, of course the smell is soon gone.

Mr. WOODWARD confirmed the observations of Mr. Burrows. If men handled the dynamite cartridges in a close store the gas given off made their heads ache, and caused sickness.

Mr. FLETCHER: I believe there has been some disturbance at a place not far from here. The men have been in the habit of using the water cartridges without the water, and this having been discovered, the reason they gave for so

acting was that frequently they had not the water at hand when a miss-fire had taken place; they had not the exact guage of the drill hole; it was too small, and had ripped the cartridge, allowing the water to escape, and they did not like the expense of getting others, or had not another bag at hand. The appointed shot firers gave it as their excuse that the men preferred the cartridges without water, as they did more work.

The CHAIRMAN: You use them at Atherton, Mr. Burrows?

Mr. BURROWS: To some experimental extent, but they are a lot of trouble. The hole has to be drilled to a nicety. I think the drills are 2¾in. (2½in. being for the cartridge), and if the hole should be a trifle too small it tears the bag, and if too large it wastes the space. If you drill a hole three inches, the space on each side of the cartridge takes away from the effect of the shot. The cartridges are, besides, expensive.

The CHAIRMAN: Have you had the difficulty of the water running out?

Mr. BURROWS: Hitherto the work has been done by the underlookers—men who are very careful,—but in the hands of an ordinary miner no doubt that would soon happen. They always tallow the neck, or water would run out while they are stemming the hole.

Mr. HALL: I understand there is a rumour that the explosion in South Wales was caused by one of these gelatine dynamite cartridges. Has any one information of that?

The CHAIRMAN: The newspaper account said that they were using the cartridges without water. In all the experiments I have seen made with Mr. Settle's cartridge I have never observed any sparks from it. I have seen it fired in

exceedingly fine dry coal-dust, and it has not ignited it; but a shot of powder in the same makes a great flame.

Mr. HALL: Yes, no doubt there is a great difference in the flame; but if there is difficulty in keeping the water in we ought to seek for a remedy of that as soon as possible.

The CHAIRMAN: There have been so many explosions from gunpowder in the mines that it is quite clear something will have to be be done, either by the use of high explosives, or by dispensing with powder, to keep matters safer for the future. It seems that explosives cannot be wholly dispensed with, and the coming thing seems to be these high explosives—such, for example, as that described to the North of England Engineers a month ago under the name *Securite*, a mixture so combined that the explosive substance is in a more condensed form than when surrounded by water. But I have not heard whether that invention has got any further than on paper.

Mr. COCKSON: I should like to ask if any gentleman using the water cartridge has had my experience, which is that neither Mr. Settle's nor any other form is effective in some mines. I am sure that my wish to give these high explosives a fair trial has also actuated others; I have done my best to see if they would work as effectually as indicated; and I must say I feel much discouraged at the result. I have given two days to it myself. I find that the work cannot be done with the water cartridge as effectually as it can be done with gunpowder. The experiments were carried out in the Wigan Six-feet, which, with us, I should not call a fiery mine; either the explosive was not proportioned to the work, or for some other reason, it failed to do the work; and I am anxious to know whether you have had the same experience.

Mr. BURROWS said: We find that bobbin powder is preferred to gelatine dynamite with the water shield; but the

latter would be improved by proportioning the dynamite to the work it has to do. I think we can do as much with the dynamite as with powder; still I think there is a loss of power, as I said, owing to the cartridge not fitting exactly to the hole. I think also that water, around the dynamite, deadens the force of the blow considerably.

The CHAIRMAN: If the dynamite is not so economical as gunpowder, it should be borne in mind that only one or two of the Six-feet mines in the Wigan district have escaped serious explosion with powder in use.

Mr. COCKSON: We cannot get power enough out of the cartridge to do the work. The gentlemen who came to experiment commenced by saying that the explosive was so much stronger than powder; and, in order to be on the safe side, they did not give it that proportion of extra work to do—they gave it a much smaller proportion—but still it was not effective; it did not stir the coal sufficiently; and at the end of our experiments we were using twice the quantity of explosive they estimated would be necessary. Then, after the shots had been fired, we had to waste several hours getting the coal: fifty per cent. of the work had to be done by hand. It was not so much a question of extra cost as that we could not get the explosive to do the work. The nature of the explosive did not seem fitted to the character of the mine, however strong the charge used.

Mr. HERBERT FLETCHER said that, in the county of Durham, Messrs. Atkinson's investigations showed that the recent explosions were all traceable to shot firing in the main haulage roads. Their conclusion was that gas had little or nothing to do with these explosions, the force having been almost invariably towards the working places.

The CHAIRMAN: I have investigated some hundreds of explosions, but I have never investigated one yet where it

was entirely attributable to dust. I think there is a good deal of dust thrown in people's eyes in regard to this matter. Explosions have always been from fire-damp, aggravated, no doubt, by coal dust in many cases.

Mr. BURROWS said he was satisfied that, where the water cartridge was properly put in, that there was no fear of either gas or dust being lighted by the shot. How it would be if left to the ordinary shot-firer, who had to do so many in a night, he could not say; but under proper supervision he thought there was no fear whatever of sparks.

The CHAIRMAN observed that there was sufficient in the subject to enable them to return to the discussion at a future time.

THE ARGUS SAFETY LAMP.

Mr. WILLIAM DUXBURY, C.E., exhibited the "Argus" safety lamp, the subject of recent experiments at Sheffield, and explained its merits. He read the following communication thereon from Mr. Beresford Bennett:—

In addressing the members of this Society upon an improved safety lamp, I need not go minutely into all the attempts which have been made to render safe the work of the coal miner, and yet to supply him with a sufficient amount of light. To Davy practically belongs the credit of applying a scientific appreciation of the temperature of ignition to the construction of a lamp which might be carried with safety into an atmosphere of explosive composition, and few more interesting instances can be found of the adaptation of scientific principles to practical purposes than that of utilising the great conducting power of metallic wires, in the form of gauze, to make at once an envelope

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capable of transmitting light, and of so reducing the temperature of the enclosed ignited gas as to prevent chemical combination outside.

But however we may applaud the scientific skill of Davy, it is needless to say that his lamp has often failed in use, and that because it has been required to do something altogether beyond that for which its inventor intended it. Davy himself pointed out that the lamp is no longer safe if exposed to a draught of air, as in that event the flame might be blown upon a small surface of the gauze, and thus heat it above the point of safety. Galloway's experiments (Proc. Roy. Soc. xxii., 441) proved also that a current or blast of air passing at a rate of eight feet per second might blow the flame through the gauze.

Two lamps known as "The Geordie" and "The Clanny" respectively have for some time been held in considerable favour. Still it is not unfair to say that they are not as safe as could be desired. As a consequence of the anxiety felt by those interested in the safe working of mines to obtain a lamp which should at once give a good working light, and be safe against explosion under any set of circumstances hitherto known to occur in coal-working, Mr. Ellis Lever in 1884 generously offered a prize of £500 to the inventor of a lamp which should satisfy the following conditions, viz.: To be perfectly self-contained; which could be carried; which would keep alight for not less than 12 hours; which should be incapable of causing an explosion of gas under any circumstances in actual practice. I believe the judges appointed to make the award examined 104 oil and 4 electric lamps, but were unable to recommend any of these for the prize. The "Argus" was *not* included in the 104 oil lamps, being a later invention. They did, however, commend highly a lamp known as "The Marsaut," and also a lamp invented by Mr. William Morgan, of Pontypridd,

and which is called "The Morgan." It is only fair to say that Mr. Morgan's lamp has many good features.

I will now briefly describe the lamp which is before you, and I think I may say parenthetically that it is neither clumsy in size nor appearance.

In the first place, as to the light obtained by surrounding the wick with two concentric cylinders of good tough glass, a really clear light is obtained, whilst the cylinders are so arranged top and bottom as to promote a rapid current of air between them when the lamp is alight, and so keep the glasses cool. It is most important to notice, as will be explained shortly, that should either of the glasses be broken there is no chance of explosion.

It is, however, to the arrangements top and bottom that I desire especially to call your attention, as on these depend the great safety of this lamp and its superiority over others. As I am not one of the inventors of this lamp, I think I may say without impropriety that very great ingenuity has been displayed in applying scientific principles at these points, as you see air, to enter either the centre of the lamp for the purpose of supporting combustion or to pass between the glass cylinders, must make its way *twice* through copper gauze of fine mesh, a space existing between the two gauzes. The same arrangement substantially holds at the top of the lamp. Now those of you who have had much to do with burning explosive mixtures will at once appreciate how much the successful performance of this lamp depends on the arrangement of this space between the two gauzes and the enormous resistance which is thereby offered to any sudden impulse being conveyed across it. I must again remind you that this security against draughts or sudden impulses holds as well for the space between the cylinders as for the centre of the lamp.

Whilst the gauzes are arranged so advantageously as regards safety against explosion, they are also free from the slightest risk of external injury, this I think cannot be too strongly commended.

Another feature to which attention should be called is that "drip" does not, nor can it, interfere with the working of the lamp.

I will now read the account of some experiments made at Sheffield, which I have taken *verbatim* from *The Sheffield Daily Telegraph*, Monday, March 14th, 1887, and made at Neepsend Works of the Sheffield Gas-light Company :—

"If efforts to render safer the necessary operations for supplying one of our most pressing needs are worthy of praise, then I think you will agree with me that the inventors of the Argus lamp will receive in days to come no small share, if not from those who use the comforts of life without a thought of the dangers amid which they are procured, at least from those who carry their lives in their hands in order to supply the community with that which is indispensable to its welfare. The scenes on a pit bank after an explosion are too sad to dwell upon, and any effort to render those scenes impossible seems to me well worthy of the recognition of a learned society, even though the effort may be a source of pecuniary advantage to those interested.

"Signed,

"J. A. Beresford Bennett, B.A., B.Sc., &c.,

"Birmingham."

Mr. Teale said those who have followed up the question of lamps for a long time—and our worthy Chairman will, I think, bear me out in this—have been amused with the way in which old things have been re-hashed, and old things re-produced in the guise of new lamps. I have not had the

pleasure of seeing this Argus lamp before to-day, but it reminded me at once of one invented by our friend, Mr. Williamson, of Cannock. The principle of both is the same—the double shield, ventilation below the flame, and so on—but the Argus has the merit of being the most artistic lamp I have ever known put into a miner's hands. Mr. Williamson's idea, moreover, was by no means new. If you go back to Morrison's lamp it is there; it is in a Belgian lamp still earlier, and back again to the French lamp. So it goes from one to another, and we have the same thing brought before us to-day. Now the question of lamps is in the test they will stand, and frequently as we have discussed the matter no one yet has been able to say what test a lamp should be submitted to. I will undertake to explode any lamp that has a light in it, which admits air for the support of combustion, and in which an outlet is allowed for the removal of the products of combustion. I do not say it shall be a fair test—I do not say that the conditions would be such as you would find in a mine—but the idea is to test the lamps at such a high pitch that the thing is carried to an absurd extreme. The lamp spoken of most highly in the Royal Commissioners' report was simply a Clanny lamp shielded, with the inlet reduced to the finest point, and the outlet so protected that except in a high velocity it was impossible to burn, but in a room it was impossible for the lamp to burn. It stood a high test, when you had a velocity of 60 or 80 feet per second, but in the mine, when put into actual use, it failed utterly. In this matter of lamp testing it is necessary that mining engineers should make up their minds what the actual test should be, and allow a certain amount of current beyond that in order to provide for contingencies. They should get the best light, also, from the one that is the most economical, and one which can be

carried about a colliery freely—these conditions fulfilled, and you have something like a safe lamp.

Mr. BURROWS: I saw in the newspapers the account of the experiments referred to by Mr. Teale, and I am now glad to see the lamp itself. It seems to give a very nice light. I remembered at once that Mr. Williamson's lamp, which he brought before the Coal Owners' Association six or seven years ago, was the same in principle.

Mr. FLETCHER said: The lamp exhibited by Mr. Duxbury gives a superior light, which we must all admit is the first qualification in a safety lamp. The new Coal Mines Regulation Bill is to be read a second time in the House of Commons to-morrow, and I hold in my hand a copy of it, the memorandum prefixed to which bears out my statement. The Bill leaves the question of what mines should be worked exclusively with lamps to special rules, the reason being that it is impracticable to devise any general description, which would include those mines, and those only, where the use of safety lamps is imperative; and that to impose safety lamps unnecessarily on any mine is to deprive the miner of a good illuminant—his most effective protection against his chief danger, falls of roof and sides. I think that lamp is a step in the right direction.

Mr. TEALE: I, too, have had an opportunity of reading the Mines Bill, and I think it would have been just as well if Mr. Fletcher had given us the whole of the memorandum he has in his hand as to the intention of the Bill. The intention is certainly not to dispense with the best light you can possibly get, but that lamps should be used under certain conditions—the responsibility for observing those conditions resting, of course, upon those engaged in the management of the mine. I need say nothing further; but as the Bill is going to be read a second time, it is a little too early to discuss how it will affect various collieries.

Mr. CLIFFORD gave some information with reference to the tests conducted at Sheffield, observing, in the first place, that the testing apparatus was not in order, as they were informed, before the work began. The mixture used was 1 of gas and 13 of air. The Davy lamp was not tried at all; the Mueseler was an old Johannesberg Muescler, twenty years old, with rusty gauze, and without a bonnet. To his great astonishment, the Morgan lamp fired in the same current with this after long exposure. The gas engineer found that the current had been lowered from forty-two tenths—the pressure under which the Morgan fired—to fourteen tenths when the Argus was tested. The breaking of the driving belt prevented a repetition of the tests. He would undertake to provide a lamp which he challenged Mr. Teale to fire—provided the lamp remained in the condition in which he received it—under any test that he chose to apply; and that lamp would be one which would give a good light, and burn freely.

Mr. HALL: Does the lamp go out in testing, or does it continue to burn?

The CHAIRMAN: We are now discussing this Argus lamp, not the Clifford lamp.

Mr. HALL: Does this lamp of Mr. Duxbury's, when placed in a gassy mixture, go out or continue to burn?

Mr. DUXBURY: It burns, but you can see very little appearance of gas inside.

Mr. HALL: Because I think it stands to reason that a lamp which is dependent upon glass for its safety must go out when put in an explosive mixture. If it does not go out it is only a question of time—the glass must break eventually; then where are you? The safety of the Museler and others, dependent upon glass, is that they go out.

Mr. DUXBURY: If the lamp falls over by any means it goes out.

Mr. FLETCHER: If you make a lamp that goes out the moment it gets an explosive mixture within it, and put that into the hands of a fireman, he will never try for gas in parts of the mine where gas is suspected, lest he should be left without light. Therefore, you may be undoing with one hand what you are doing with the other. You cannot go and try the state of a mine with a lamp that goes out immediately.

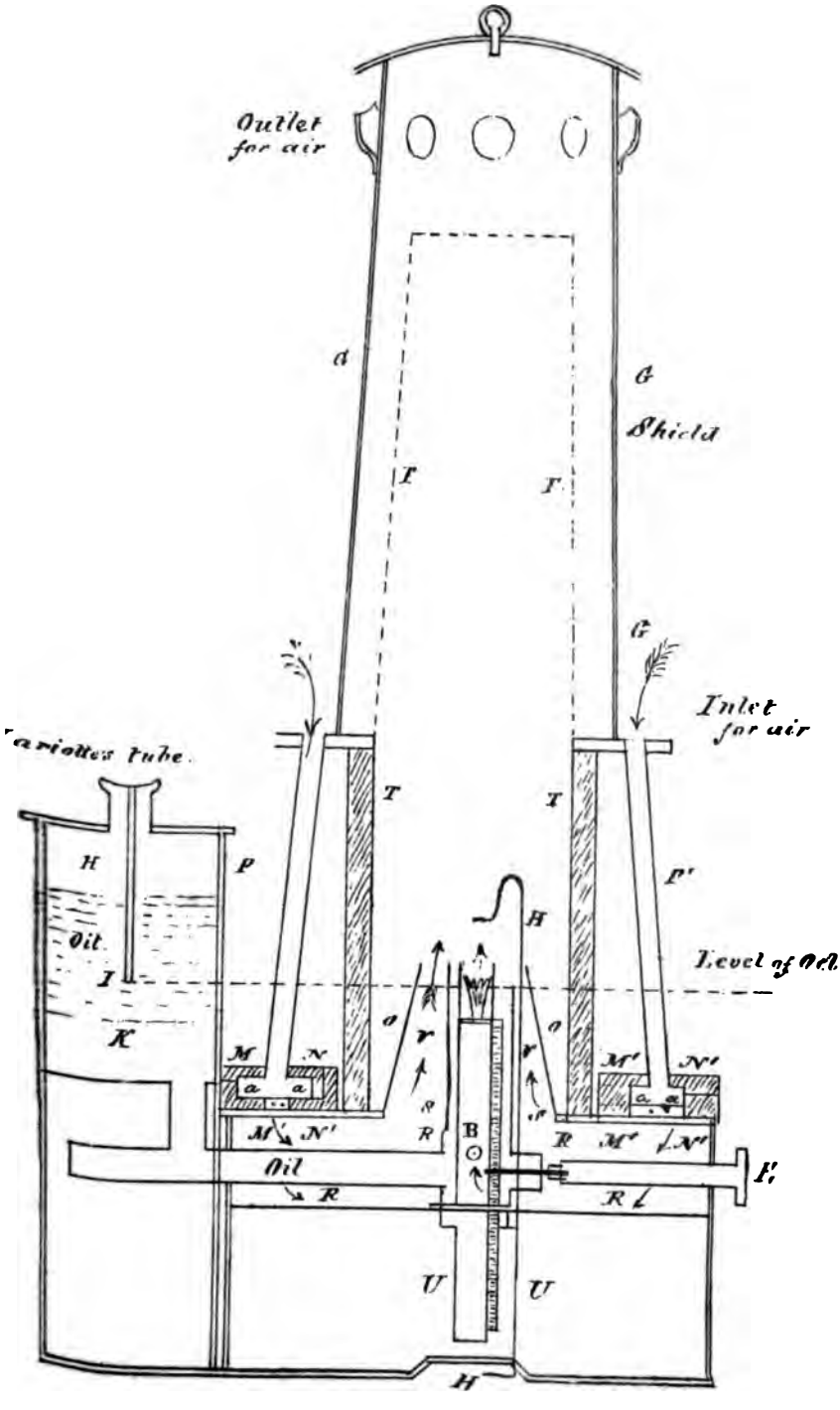
THE CAMBASSÉDÈS LAMP.

The Hon. Secretary (Mr. STIRRUP) exhibited enlarged diagrams of a new type of miners' lamp, called the Cambassédès, and read the following account of it translated from the Comptes-Rendus Mensuels, February, 1887, de la Société de l'Industrie Minérale:—

M. Cambassédès, in speaking of the various safety lamps now in use, including the Mueseler, Marsaut, and the English types of Morgan, Upton, Roberts, &c., says they do not realise the great want of the miner—an increased illuminating power combined with safety in an explosive atmosphere. He says: Lamps fed from below must be classed in two very distinct categories: Lamps of the Westphalian type, with direct feed in contact with the glass over all the surface of the lamp. These allow of the lamp being wholly filled by rapid currents containing fire-damp, and are in consequence particularly dangerous.

It is quite otherwise with lamps of the second category, for which the system Upton and Roberts may serve as type.*

* The Morgan lamp resists extinction very well in rapid currents; but it is too complicated, and does not give more light than ordinary lamps. The admission of air from below takes place through a perforated plate, then through two gauzes. The two gauzes may be advantageously replaced by increasing the thickness of the perforated plate, and then our system is arrived at.



TWO-THIRDS OF ORIGINAL SIZE.

Unfortunately, says M. Cambassédès, these various lamps are too complicated, but by selecting arrangements from them and following the advice of the chief engineer of the Peslin Mines, to burn the fire-damp as soon as it arrives, he has constructed the lamp which bears his name.

He continues: "It is possible, then, to apply the principle of feeding from below, so rational for the good illuminating power of lamps, without in any way diminishing their security.

It is this well-founded conviction which has guided me in my researches, and has allowed me to arrive at the means of applying to miners' lamps the burner with double current of air, whose advantage from the point of illuminating power, there is no need at the present day to specially mention.

It is not possible, in these notes, to give an account of the numerous experiments that have been made. I confine myself to describing the type of lamp, with intense illumination, which they have caused me to adopt.

This type, represented in the Plate, is essentially composed of an annular crown, MN, for admission of air; a burner with double current of air, VV; a cone directing the gases, OO; a lateral oil reservoir, K: finally, a glass surmounted by one or two gauzes, FF, and of a shield, GG.

The air and the explosive gases penetrate into the ring, MN, by the hollow uprights, PP^1. They afterwards traverse the perforated metal sheet *aa*, and by fresh openings carefully arranged in M^1N^1, they arrive in the chamber RS.

The explosive mixture contained in this chamber, RS, is directed upon the flame of the lamp by two holes, BB, which direct it into the interior of the burner, and by a cone, OO, which conducts the air upon the exterior circumference of the flame.

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The air and the explosive gases penetrate into the ring, MN, by the hollow uprights, PP'. They afterwards traverse the perforated metal sheet *aa*, and by fresh openings carefully arranged in M'N', they arrive in the chamber RS.

The explosive mixture contained in this chamber, RS, is directed upon the flame of the lamp by two holes, BB, which direct it into the interior of the burner, and by a cone, OO, which conducts the air upon the exterior circumference of the flame.

A screw with clutch directs the wick.

It is brought into play by the stem (or rod) *ee*, by the means of a pinion and rack.

The stem HH serves as snuffers.

The oil is supplied by the reservoir K.

This reservoir is formed by a part of the space comprised between two concentric cylinders. It is furnished with a Mariotte tube II. The height of the oil is thus rendered constant during the whole time of the combustion. It is sufficient to fix it, once for all, at some millimètres from the flame, to give to the tube II a length so that its lower extremity be even with the desired level.

The interior concave face of the reservoir serves as reflector. With petroleum the lateral reservoir K is needless.

The petroleum is put into the reservoir UU. The burner represented in the figure can be replaced by a German burner *Cosnios*, with annular wick and internal current of air.

A glass TT, a shield in sheet iron GG, one or more safety *gauzes* FF complete the system.

The fumes, after having traversed the gauze, escape at the top of the lamp. No other opening exists in the shield. The air and the gases therefore go through into the lamp solely by the bottom. This arrangement has for object and for result a considerable increase of the lighting power, with equal consumption of oil and a guarantee of complete security.

The augmentation of the lighting power and the economy of the oil realised are considerable. One may estimate the saving of oil at one-half. In the trials made with the Rumford photometer, it has been proved that for a quadruple

illuminating power the consumption of oil was scarcely double that of Mueseler lamps.

On the other hand, whilst in ordinary lamps it is very difficult to vary the lighting power without charring the wick and smoking the gauze, one is able, with my arrangement, to graduate the light without inconvenience from zero to seven or eight times the lighting power of ordinary lamps. Miners can thus, when they wish to explore the roof, clean their coal, &c., temporarily obtain all the light desirable.

The causes of this great superiority are due: (1) To the double current of air and to the gas-directing cone OO, which secure the regulated arrival of oxygen around the flame, and the immediate carrying off of the products of combustion; (2) To the heating of the air, which arrives, moreover, pure from the mixture of the fumes or of the gases already burned from contact with the flame; (3) To the invariable level of the oil, at a few millimetres from the flame.

Our lamp is not only incomparably of more illuminating power than all other known miners' lamps, but it possesses, besides, the precious advantage: (1) Of allowing the variation at will of the lighting power within the widest limits, without the wick smoking or charring; (2) Of keeping, up to the last minute, a constant lighting power, whilst ordinary lamps notably diminish their luminous intensity at the end of their term.

The security is as satisfactory as the lighting power. Numerous trials with illuminating gas, in mixtures dosed and undosed, have proved it. There is nothing very astonishing about that. The fire-damp and the air can circulate only in contact with the flame in a very restricted zone, in which the fire-damp burns as soon as it arrives.

In placing oneself in the most defective conditions, with the small flame, the fire-damp can only fill a cylindrical surface in the lamp, having for base the diameter of the summit of the cone OO, whose diameter is only two centimétres, less than the half of the diameter of the Mueseler and Marsaut lamps. Every part comprised between the cone and the glass plays the part of the neutral plug, whose influence is well known since the memorable experiments of Bessèges. The orifices for the entrance of the air, which constitute the weak point of lamps fed from below, are protected by the gauze *aa* and the tubes PP', the superior extremities of which might be easily protected by the addition of other gauzes.

But have not the risks of the lamps been exaggerated? The want of supervision or the defects of construction are certainly much more to be feared.

The roughness of the setting, the want of the efficient tightening of the glass of the lamp at the bottom of the gauze, may occasion explosions. Many times this has proved to be so.

Therefore the Marsaut arrangement for the bottom of the gauze, with holes giving a certain elasticity to the envelope, is to be recommended.

The facilities of extinction are, moreover, not to be disregarded.

All lamps are in fact susceptible, in an inflammable atmosphere, of permitting the fire-damp in the interior to burn.

The glass then gets heated and breaks, or the plate reddens.

It is necessary, then, to be able to extinguish the lamp, which can easily be done with the shielded lamps, in closing the openings for the admission or exit of the gases with a

Unfortunately, says M. Cambassédès, these various lamps are too complicated, but by selecting arrangements from them and following the advice of the chief engineer of the Peslin Mines, to burn the fire-damp as soon as it arrives, he has constructed the lamp which bears his name.

He continues: "It is possible, then, to apply the principle of feeding from below, so rational for the good illuminating power of lamps, without in any way diminishing their security.

It is this well-founded conviction which has guided me in my researches, and has allowed me to arrive at the means of applying to miners' lamps the burner with double current of air, whose advantage from the point of illuminating power, there is no need at the present day to specially mention.

It is not possible, in these notes, to give an account of the numerous experiments that have been made. I confine myself to describing the type of lamp, with intense illumination, which they have caused me to adopt.

This type, represented in the Plate, is essentially composed of an annular crown, MN, for admission of air; a burner with double current of air, VV; a cone directing the gases, OO; a lateral oil reservoir, K: finally, a glass surmounted by one or two gauzes, FF, and of a shield, GG.

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The security is as satisfactory as the lighting power. Numerous trials with illuminating gas, in mixtures dosed and undosed, have proved it. There is nothing very astonishing about that. The fire-damp and the air can circulate only in contact with the flame in a very restricted zone, in which the fire-damp burns as soon as it arrives.

not perfect! Has not every medal its reverse? all progress its inconvenience? The placing of the wick is most difficult, the price of the lamp is rather high, and its oil reservoir gives it an ungraceful form, which seems at first inconvenient.

Nevertheless, the lamp fixed above by the hook, below by the clasp, follows without inconvenience the movements of the body.

The boss leaning against the breast protects it against the heating of the shield.

It inconveniences little, and is useful in many circumstances, notably as reflector to project to any wished for point an intense ray of light.

It is incontestable that with a lamp of increased power, the skill and strength of the miner would be much better utilised; there would be less coal wasted in the *gobb*; the product would be cleaner, more merchantable, which is not to be despised at the present time; and finally the all-important question of safety will have made a grand stride, since the miners will be able to see all the causes of danger, especially the fissures which occasion so many falls, causing more than half the accidents of the mine.

The English Commission of Accidents in Mines has recently admitted this, and has strongly recommended a greater illuminating power of the lamps.

In all the works of the mine, the lamp with central current of air will considerably increase the useful action and security; we think also, notwithstanding the disadvantages, altogether secondary, of detail and of form which we shall be able moreover to modify, that it merits all your attention.

The tube MM' serves as the oil reservoir, the air enters directly from below, or by the hollow columns which protect the glass.

The breaking of the glass is the only current expense which can balance the great illuminating power and the economy of oil realised and the glass solidly fixed costs less than 0f. 15c."

A commission nominated by the Society 16th January, 1887, was empowered to make experiments with this new safety lamp and compare it with those of the best known and recommended types.

Mr. THEW exhibited a new lamp which was described in the following paper :—

A GAUZELESS SAFETY LAMP.

BY MR. GEORGE THEW.

In constructing this lamp I had five qualifications in mind that I thought essential.

1. That it should be safe.

2. That if there was any gas, that it should be seen at a glance, and that the light should automatically call attention to it.

3. That the miner should have the means of cutting off the light instantly without disturbing the lamp.

4. That it should have light sufficient to work by.

5. That it should be simply constructed so that the miner could understand it, and that it should not be liable to get out of order.

1. In respect to safety, the lamp is so constructed as to limit the amount of air to the requirements of the light, and if gas is supplied instead of air, the light from the wick is diminished or put out, according to the amount supplied ;

and the gas is limited to such an extent as to rende
harmless; the feed being at the bottom, the flame m
of necessity pass through the tube and out at the top, a
in going this distance and passing through the gauze a
holes in the top it is so cooled that it is impossible to p
through at such a heat as to cause danger of explosion to
outside.

2. That if there should be any gas, it should be seen at or
The feed being at the bottom, the gas, if any, must sh
opposite the glass, and must attract the miner's attenti
because it will diminish or put out the ordinary light; a
being subdivided by these small holes is almost without li
itself, as an ordinary gas burner with 100 or 200 holes inst
of one or two the light would not be as great.

3. That the miner shall have the means of cutting off
feed instantly without disturbing the lamp, I have paten
a slide to go over these holes which can be turned on in
instant without lifting or disturbing the lamp, but the m
forgot to put it on, and we had no time to remedy it.

4. That it should show sufficient light to work by. I c
see to read by this and can see a pin six yards off. I co
tend you can give a good light without danger if you ha
cooling surface enough exposed to the air, and the flame
enough away from the point where it comes in contact w
the outer air.

5. That it shall be simply constructed and not liable
get out of order. This lamp is constructed like the c
lamp; the tube represents the gauze without its danger in
current, the bottom is put in like the ring that supports t
glass, but is a solid plate, so far as it prevents the fla
passing back through it.

LAMP TESTING APPARATUS.

The CHAIRMAN, speaking of Mr. Thew's lamp, said: The way in which this lamp comes before us is this. The inventor wrote to me asking if I could get the lamp tested for him. Now a testing apparatus for lamps is a thing very much wanted in this district. I know of none. What we need is a testing apparatus open to any one on payment of a small fee, so that every lamp may be tested under circumstances which shall ensure freedom from any commercial bias. It seems there is an apparatus at Sheffield. There was one at Mr. Smethurst's Colliery, near Wigan, but I think the Royal Commissioners after using that either took it away or improved upon it so much that it was removed to Woolwich. In 1883, when I wanted a Marsaut lamp tested there was not a place in the neighbourhood to which it could be sent. I applied at Woolwich, but there it was cold-shouldered, and at length I had to fall back on my friend Mr Green, of Monmouthshire. I had the lamp tested there. At a meeting of the Board of Examinations for this district in December last we discussed the matter, and we thought Owens College was the proper place at which it should be taken up. Time has passed, however, and it has not been taken up, and we are still without apparatus for the testing of miners' lamps. I wish gentlemen would consider what is the best means of getting this want supplied.

Mr. MCKINLEY said he believed the Wigan Coal and Iron Company were erecting an apparatus similar to that at Aldwark Main.

Mr. CLIFFORD said he thought the gas authorities were the proper people to take the matter up. In Sheffield they

had done this. They considered the coal interest and the gas interest very much bound up together, and on that ground it was their duty to take it up.

The CHAIRMAN said he hoped it would be taken up. Owens College would be a very suitable place, and the tests conducted there would be thoroughly reliable.

After the close of the ordinary business, Mr. Herbert Fletcher informed the members that he proposed to invite them to visit the working arrangements at Ladyshore Colliery at an early date; and he afterwards explained some matters of interest in connection with that colliery.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

RT IX. VOL. XIX. SESSION 1886-7.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held Friday, the 6th May, 1887, in the Mining School, Wigan.

Mr. ROBERT WINSTANLEY, a Member of the Council, in the Chair.

DUST IN MINES.

A discussion was taken on Mr. M. Mercier's paper on "Dust in Mines," read at the Wigan Meeting, in January last. (*See Part IV., Vol. XIX., page 94.*)

Mr. J. S. BURROWS said he thought that in the paper Mr. Mercier spoke of several methods of lessening the quantity of dust, such as making tubs in a better fashion and so on, but it seemed to him (Mr. Burrows) that much of the dust was caused by the tubs going at a rapid pace against a strong current of air, and particularly when the wheels of the tubs were small. Since the paper was read he had made inquiries and found that where the roads were packed the

dust had gone a long way in the pack. Where there were any open spaces the fine sooty dust seemed to have lodged. He swept one place on a horse road and took notice of it, and within less than a week it was heavily coated with the same fine dust. So that it seemed it would be much easier to do without powder in main roads than to lay the dust. Where the road was paved and the dust lay thickly, the water ran away in little globules, and if much water was put on, the timber became wet, made it slippery for the horses, and the water would tend to lift the floor. Hence he thought that people would rather find some substitute for powder in getting the roof down than taking such trouble as would be necessary to effectually lay the dust.

Mr. MAWSON thought the idea of having pipes through the workings was a good one, but in view of the expense that would be involved, it was hardly practicable. In his judgment the best suggestion in the paper was that which had reference to the distribution of water in the form of spray, after the manner in which streets were watered.

Mr. BURROWS asked how far would an ordinary tank—a big one—lay the dust on a road one thousand yards long? It seemed to him that a fabulous quantity of water would be required.

Mr. MAWSON said there was no doubt a large quantity of water would be required to lay the dust as it now existed, but the question was, if that dust could be swept away, and the road once cleaned, and water tanks were constantly used, would the roads get dusty to the same extent as now?

Mr. BURROWS replied, that so great was the quantity of dust produced, that in a double road 900 yards long, 18

tubs of dust were gathered every day. There were two men in every night getting timber down, and they regularly filled 18 tubs with dust.

Mr. H. HALL, H.M. Inspector of Mines, remarked as regarded the dust blowing off the tubs, perhaps that could be prevented by watering the tubs as well as the road. It seemed to him, that if water was sprinkled on the tubs, there would be less chance of dust blowing off. He thought this question of dealing with dust in mines was a very important question, and that it would have to be dealt with in one shape or another. He read the other day a description of a new sprinkling machine brought out by somebody in the north, he thought, and if he remembered rightly, it was said they could water 800 yards of road with something less than one thousand gallons of water. The description went on to show that there was a tank on wheels, and that it had a tail projecting at the back which was caused to revolve by traction, and there were holes in the sprinkler, like those in town water-carts, but the tube was placed longitudinally instead of crosswise. So far as lifting of the road was concerned, managers expected there would be difficulty in that direction. No doubt there was a good deal of difficulty on some kinds of roads, but he imagined that if they persevered with the watering, and got the temperature of the bottom something like regular, a good deal of that would cease. He thought it very important, that somebody should try to invent a ready means of watering the roads. He had thought sometimes it might be possible to wet the air as it were that goes into the collieries, but he had asked one or two scientific men who were likely to know, and they did not hold out much promise of that being done. He thought that watering the tubs would prevent dust blowing off to some extent. The only objection he saw to such a

practice was that the tubs would weigh a little more when arriving at the surface.

Mr. M. MERCIER, in replying to the various questions and remarks, said there appeared to be rather a mistaken notion as to what should constitute the proper watering of dusty mines. What was required was not the sprinkling of water on the floor, which would, as Mr. Burrows remarked, run about like quicksilver and do very little service. The water should be so mixed with the air in the form of a very fine spray to give it something of the nature of a Scotch mist. In this condition the fine particles of dust became saturated with moisture, and falling to the ground, or settling on the roof, sides, and timbers transmitted the surplus moisture to the other dust particles. If the mine be watered in this manner the moisture would have but little, if any, injurious effect on the warrant or roof. The diffusing of this fine spray or vapour had been successfully accomplished at numerous collieries, and more particularly so in the South Wales coalfields, by the use of jets of water and compressed air, the latter giving to the spray an exceptional fineness. Compressed air was not, however, needed where a head of water could be obtained to give a pressure of 40lbs. to 50lbs., and provided the holes in the jet were fine. At Messrs. Smethurst's collieries the special form of cart mentioned in the paper under discussion gave excellent results, and by centrifugal force delivered water in fine sprays from the circular rose or perforated disc, which was scattered on the roof, floor, and sides of the roadway, through which it passed, and very effectually damped the whole air travelling in the road. As far as he could remember an ordinary sized water cart would effectually damp the dust in a main haulage road, with a double line of rails for a distance of from 300 to 500 yards. What

was most required with a cart of this description was an automatic shut-off, so arranged that no water should run out whilst the cart was stationary. He believed that this method would be much more costly than laying pipes in the main haulage roads and airways, which latter system would be of very great service in the case of a fire in the mine. With reference to the production of dust by badly constructed and open boxes, he could not agree with Mr. Burrows that the dust was chiefly caused by the small particles blown off the top of the tubs during transit. The South Wales collieries, which were noted as being more dusty than collieries in other districts, owed it nearly all to the open form of box in use and bad roadways. At one colliery, in the South Wales coalfield, the manager, by introducing a better class of road and rail, and substituting closed for open tubs, had reduced his quantity of dust two-thirds. He (Mr. Mercier) had noticed in all collieries in which iron boxes were used that there was very much less dust produced than by those in which wooden tubs were solely used.

The CHAIRMAN, in closing the discussion, said the subject was most interesting to colliery proprietors and managers. He had been told, on excellent authority, that the practice of watering the roads was much on the increase in South Wales.

Mr. Herbert Fletcher was to have read a paper on "The Working Arrangements at Ladyshore Colliery," but in view of the fact that those arrangements were the subject of a legal inquiry, he deemed it best not to say anything formally about them at this meeting.

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It was thereupon agreed, on the motion of Mr. Burrows, seconded by Mr. Caldwell, that the reading of the paper be postponed to a future meeting.*

This concluded the business.

* *On the invitation of Mr. Fletcher the members had previously had the opportunity of visiting the Colliery, viz., on Friday, 29th April, and Monday, May 2nd, and of personally inspecting the workings and appliances at Ladyshore.*

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XIX. SESSION 1886-7.

The ORDINARY MEETING of the Members was held on Tuesday, June 7th, 1887, at the Rooms of the Manchester Literary and Philosophical Society, George

ADDENDUM.

PART X. VOL. XIX.

Plate I.—Fig. 1 reduced to one-third the natural size.
,, ,, 2 reduced to seven-sixteenths the natural size.
,, ,, 3 reduced to one-half the natural size.
,, ,, 4 Natural size.
Plate II.—Figure reduced to one-third the natural size.

The following are the recent additions to the Library.—

Cambridge: 21st Annual Report of Museums, &c., Syndicate.
——— The Earth History of the Remote Past, Pamphlet, by J. E. Marr.
——— Notes on the Geology of the Vale of Clwyd, Pamphlet, by T. Mc.K. Hughes.
——— On some Perched Blocks, Pamphlet, by T. Mc.K. Hughes.
——— On the Geology of Anglesey, Pamphlet, by T. Mc.K. Hughes.
——— Hippopotamus, from Barrington, Leaflet, by Philip Lake.—*From Professor Hughes, Woodwardian Museum.*

Chesterfield and Midland Counties Institution of Engineers, Pa
Vol. XV.; Sections of Coal Measures, Part 7, Vol. XV.—
the Institution.

Cornwall, Royal Geological Society of: Transactions, Part 1, Vol.
From the Society.

——— Mining Association and Institute: Transactions, Pa
Vol. III.—*From the Institute.*

Devon and Exeter Albert Memorial Museum: 17th Annual Report

Dublin—Royal Dublin Society: Scientific Proceedings, Parts
Scientific Transactions, Parts 11-13, Vol. III.—*From the Soci*

Essex Naturalist, Nos. 3-4.—*From the Essex Field Club.*

Glasgow—Natural History Society of Glasgow: Proceedings and
sactions, Part 3, Vol. I.—*From the Society.*

Hertfordshire Natural History Society and Field Club: Transac
Part 5, Vol. IV.—*From the Society.*

Leicester Literary and Philosophical Society: Transactions, Part
1887.—*From the Society.*

London—Geological Society's Journal, No. 170, Vol. XLIII.—*Fro*
Society.

——— Royal Society: Proceedings, Nos. 253-254, Vol. XLII.—
the Society.

——— Institution of Mechanical Engineers: Proceedings, N
1887.—*From the Institution.*

——— Royal Institution of Great Britain: Proceedings, No. 80,
XI., Part 3.—*From the Institution.*

——— Geologists' Association: Proceedings, No. 1, Vol. X.—*Fro*
Association.

——— Palæontographical Society; Vol. XL., for 1886.—*Purchase*

——— Geological Magazine, Nos. 273-5.—*Purchased.*

——— Official Year Book of Scientific and Learned Societies of
Britain and Ireland, 1887.—*Purchased.*

——— British Association Report: Birmingham Meeting, 18
Presented by the Association.

Manchester Microscopical Society: Transactions and Annual R
1886.—*From the Society.*

Midland Institute of Mining Engineers: Transactions, Parts 86-
From the Institute.

Mining Institute of Scotland: Transactions, Part 1, Vol. IX.—
the Institute.

North of England Institute of Mining and Mechanical Engin
Transactions, Part 11, Vol. XXXVI.—*From the Institute.*

North Staffordshire Naturalists' Field Club: Annual Report
Transactions, 1886.—*From the Club.*

Oxford—Radcliffe Library Catalogue, 1886.

Stirling Natural History and Archæological Society: Transactions, 1885-86.—*From the Society.*

Yorkshire Geological and Polytechnic Society: Proceedings, Part 2, Vol. IX.—*From the Society.*

Canada—Royal Society of: Transactions, "On the Fossil Plants of the Laramie Formation," by Sir J. W. Dawson.—*From the Author.*

——— Toronto—Canadian Institute: Proceedings, No. 2, Vol. IV.—*From the Institute.*

U.S.A., California State Mining Bureau: 6th Annual Report of State Mineralogist, Parts 1 and 2.—*From the Bureau.*

——— Cambridge; Harvard College: Museum of Comparative Zoology, Bulletin, No. 3, Vol. XIII., "Simple Eyes in Arthropods," by E. L. Mark.—*From A. Agassis.*

——— Columbus, Ohio: Preliminary Report upon Petroleum and Inflammable Gas, with Supplement, by Edward Orton, State Geologist.—*From the Author.*

——— Minnesota: The Geological and Natural History Survey of: 13th and 14th Annual Reports, 1884-85.—*From N. H. Winchell.*

——— New York: American Museum of Natural History: Annual Report of Trustees, 1886-7.—*From the Trustees.*

——— Philadelphia: Journal of Franklin Institute, Nos. 736-738, Vol. CXXIII.—*From the Institute.*

——— Philadelphia: Academy of Natural Sciences: Proceedings, Part 3, Oct.-Dec., 1886.—*From the Academy.*

——— Washington: Mineral Resources of United States, 1885.—*From the Government.*

——— Washington: U.S. Geological Survey: Geological History of Lake Lahontan. Monograph, Vol. X., "Dinocerata," by O. C. Marsh.—*From the Government.*

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Sydney—N.S.W.: Report of Trustees of Free Public Library, 1885-6, 1887.

THE UTILISATION OF MARSH, OR NATURAL GAS.

Mr. STIRRUP said: Before proceeding with the reading of the papers announced in the circular, I would like to refer to a subject which has been recently discussed by the Society. It would be in the recollection of the members that at our February meeting, a paper by Mr. G. H. Kinahan was read on Marsh or Natural Gas, and the use that is being made of it in some towns in the States of Pennsylvania and Ohio. Since that period, although so recent, there has been an increasing amount of interest taken in the subject of this Natural Gas both by explorers and speculators, and the excitement consequent thereon has now spread to adjoining States. The oil and gas belt region has been found by borings to extend through Indiana, and the prospect of this untold wealth has produced in Indiana, what in American parlance is known as a great "*boom*" in oil and natural gas companies, in consequence of which real estate in the lucky districts has gone up in value by leaps and bounds. A correspondent of mine, Mr. W. H. Fogg, in Indiana, knowing that the subject had been brought before this Society, has sent me a batch of newspapers from Indianapolis, in which an account is given of the extraordinary str

that prevails in many of the towns of the favoured States in consequence of this discovery of what we may call a new power, which Geologists scarcely dreamed of before the use that was made of it at Pittsburg some years ago.

To show the activity and excitement that at present exist, it is stated that the first company which was formed to drill for natural gas in Indiana dates only from March 5th, 1886. Since that date (up to May 8th) 118 companies have been formed, and from two to five per day are being added to the list. Three-fourths of this number have been registered only during the present year.

The rough sketch map before you shows how it is proposed, by means of pipe lines from the wells around Indianapolis, to convey the gas for lighting and heating purposes, which is to supply the needs both of house and workshop. Several towns in Indiana, enriched by this new discovery, are offering tempting advantages to the capitalist and manufacturer. Free land, free water, and free gas will be granted to large mills and factories that may be established in their midst.

It is predicted that the natural gas region of Ohio and Indiana will be the seat of the greatest aggregation of manufactories in the world, and of a productive activity unparalleled in history. Whether the prospective advantages thus proclaimed will be realised are as yet uncertain, but if they are, even in a moderate degree, it will puzzle the already over-weighted British producer to maintain his own, when his American cousin is offered fuel for lighting and heating free of cost. The inducement thus offered to the capitalist is very great, and it seems to me that we on this side of the Atlantic may have to succumb to the greater natural advantages which the United States offer, as we have nothing that will enable us to compete with them in this respect.

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GENERAL SECTION OF THE LOWER COAL MEASURE AND MILLSTONE GRIT ROCKS IN THE FORES OF ROSSENDALE, WITH REMARKS ON SOME O THE FOSSILIFEROUS BEDS CONTAINED THEREI

By Mr. Crispin Dugdale.

GENERAL SECTION.

Beds in Descending Order, Commencing about 220 yards below the Arley Mine.

No.		Ft. I
1.	Sand rock, rather coarse and false bedded	30
2.	Dark coloured shale, near the base a bed of *Goniatites* and other fossils	65
3.	Sandstone rock, very fine grained, bluish colour	11
4.	Black shale, in which are found *fish teeth* and *scales*. Reap's Clough, Bacup	70
5.	Forty Yards, or Upper Mountain Mine Coal, with 3ft. of good fireclay underneath .... 1ft. 3in. to 1ft. 6in. and	1 1
6.	Rocky bands	5
7.	Shale, very dark in colour	36
8.	Coal, with 4ft. of fireclay under	0
9.	Shale, very dark in colour, with bed of marine fossils	56
10.	Coal, Upper Foot. On top of this bed limestone nodules containing *Goniatites Listeri*, &c., occur	0
11.	Black shale	10
12.	Sandrock, false bedded	30
13.	Mountain Mine, or Gannister Coal, in roof of this seam fossil plants abound .... 2ft. 6in. to	3
14.	Fireclay seating, full of rootlets .... 6ft. to	12
15.	Black shale	6
16.	Micaceous rock, fine grained	9
17.	Lower Foot Coal (with fireclay seating, 2ft. to 4ft.)	0
18.	Dark shale, with nodules containing fossil shells..36ft. to	46
19.	Coal or Bassey Mine (Lower Yard Mine of Saddleworth)	2
20.	Fireclay	2
21.	Shale, with Ferns, Calamites	6
22.	Sandrock (Woodhead Hill rock), fine grained	24

No.		Ft.	In.
23.	**Brown shale**....	36	0
24.	**Black shale, with fossil shell bed**..	50	0
25.	**Coal**	0	10
26.	**Fireclay seating**.... .... 1ft. 6in. to	2	0
27.	**Sandrock (Upper Rough Rock)**	50	0
28.	**Coal** (Feather-edge), ferns, &c., occur when there is a shale roof	1	2
29.	**Sandrock (Lower Rough Rock)** .. .. 24ft. to	34	0
30.	**Shale, dark drab colour, with *Modiola Macadami* near the base**	30	0
31.	**Flag rock, a few *Ferns* interspersed**	44	0
32.	**Brown and drab shale**	130	0
33.	**Black shale, near the base *Goniatites Listeri*, and other shells are found**	20	0
34.	**Strong brown shale**..	20	0
35.	**Flag rock (Haslingden flag rock), *Calamites*, *Sigillaria*, *Ferns***	27	0
36.	**Brown and drab shale**	33	0
37.	**Flag rock, ripple marked. *Cordaites* at Elton Bank, Edenfield**	44	0
38.	**Brown and drab shale**	98	0
39.	**Black shale, with bed of marine shells**	35	0
40.	**Coal (top coal of Brooksbottom series)**	1	3
41.	**Micaceous shale**	40	0
42.	**Sandrock, fine grained**	20	0
43.	**Coal (bottom Coal of Brooksbottom series)**	1	4
44.	**Rocky bands**	16	0
45.	**Black rock**	0	9
46.	**Shale, with marine shell beds**	100	0
47.	**Black rock**	3	0
48.	**Drab shale, with marine shell beds** .... 15ft. to	40	0
49.	**Flaggy rock** .... 15ft. to	20	0
50.	**Shale, very dark in colour**....	24	0
51.	**Sandrock, false bedded**	5	0
52.	**Blue shale. Ferns plentiful in it**	3	6
53.	**Coal, at Ravenshore**	0	3
54.	**Sandrock, in places full of plant remains, Calamites, &c...**	60	0
55.	**Brown shale**..	30	0
56.	**Coal**	0	¼
57.	**Shale**....	10	0
58.	**Sandrock**	27	0

No.		Ft.	In.
59.	Shale	5	0
60.	Coal	0	6
61.	Sandrock	42	0
62.	Shale	4	0

At the request of your Secretary, Mr. Stirrup, I have been induced and encouraged to put together the following particulars of the rocks of a district with which I am intimately and practically acquainted.

The details of the section which I lay before you are not all obtained from one place, but are gathered from an area of five or six miles; the reason of having to go over so great a distance being that the fossiliferous beds, which I specially want to mention, are not always accessible in any one locality, but have to be followed for two or three miles, until a convenient spot for examination presents itself.

No doubt the rocks of this district are pretty well known, also the fact that certain portions contain fossils, but I have never seen any account in which any particular place is mentioned where fossils are to be got.

Having rambled up and down this district for nigh twenty years, and poked with my hammer in every bit of bare rock I came across, I have been able to find several fossiliferous beds, which I have no doubt it will be of interest to some of the members to know where to find.

It is very easy to get fossils when you know where to go, but when you have to search about for years, it is rather different.

I have found several of these beds, and I have no doubt there are more, but the great difficulty is to find the strata bared where these fossil beds occur.

I have gone a dozen times to some of these places, and have found something fresh almost every time.

I am sorry that I am not able to lay before you fossils from all the beds that I shall mention, but I have had

plenty from all of them, but have kept giving them away, and since my connection with this Society, the state of my health has not allowed me to go in search of more.

I have been astonished at times to find these fossil beds continuous over such a large area, and so constant are they in character, that I can readily determine their stratigraphical position.

For instance, I found certain fossils at Bonfire Hill, Crawshaw Booth, and then hearing they were working in the same beds at Bacup, I wrote to a friend to look for some special fossils that I named, and he found them.

The section commences at Tooter Hill, above Bacup, at an elevation of 1,420 feet above sea level.

1.—About 30 feet of sand rock rather coarse and false bedded, but where it is well developed, it gives a capital paving sett. It is extensively worked at Warmden, near Accrington, for that purpose. It is known as *Tumbling Cob Rock*, but where it received this name, I do not know.

2.—About 65 feet of very dark Shale; about 3 feet from the bottom of this shale is a bed of *Goniatites*, *Aviculo-Pectens*, and *Posidonomya*, which can be seen in a small quarry on Heighter Hey, near Sharneyford.

3.—11 feet of very fine grained, bluish Sandstone rock. It contains some trail-like markings and produces a quantity of flags on Heighter Hey. This rock is to be seen at the top of Reap's Clough, near Tooter Hill. (No special fossils.)

4.—Seventy feet of black Shale which towards the bottom contains a quantity of fish teeth and scales, but they do not lie in any particular portion.

This shale is barren of *stone rows* except a few ironstone nodules, and can be seen in Reap's Clough.

5.—The 40 yards or Upper Mountain Mine Coal (uppermost seam of Lower Coal Measures) which is from 1 foot 3 inches to 1 foot 6 inches, and 1 foot 11 inches,

and is a very fair quality of coal, but it contains a quantity of sulphate of iron, or as the colliers call them "*brass lumps.*"

This coal has been extensively worked around Bacup, and can be seen cropping out all along the hill sides. Under this coal there are 3 feet of very good fire-clay, used for making fire-bricks.

6.—Five feet of rocky bands, that is a layer of rock and then a layer of shale.

7.—Thirty-six feet of very dark Shale, which contains a quantity, of what appears to me, of iron-stone in layers of 1 inch thick to 4 inches. These layers do not run quite regularly, but appear to change about a little. Unfossiliferous.

8.—Two inches of very good coal, under which there is about 4 feet of fire-clay which contains a quantity of gannister cobs.

9.—Fifty-six feet of very dark Shale, nearly black. About 8 or 9 feet from the bottom of this shale there is a very small bed of fossils about half an inch thick of very small shells, *Posidonomya Gibsoni* found in Reap's Clough opposite a house called Pasture Bottom (not marked in the Ordnance Map).

10.—Under this shale 8 inches of very good Coal called the *Upper Foot;* on the top of this there is a large quantity of limestone nodules containing numerous fossils as *Goniatites Listeri, Aviculo-Pectens, Posidonomya Gibsoni, Orthoceras,* sp. *Vide* Fig. 1, Plate I., a polished piece of a limestone nodule, showing the fossils.

11-12.—Under the above mentioned small coal there is 10 feet of Black Shale, then 30 feet of false bedded Sand-rock which may be seen in Oaken Clough, near Bacup.

13.—Gannister, or Mountain Mine Coal, which is 2 feet 8 inches thick at Oaken Clough, but varies a little from 2 feet 6 inches to 3 feet at other places.

It is no less strange than true that the small coal of 8 inches thick occurring 40 feet above the Gannister Mine, unites with the underlying Gannister Mine, and forms a 5 feet seam, about 1½ miles east of Bacup. After the union the coal is not so good, and the 30 feet of false bedded sand rock disappears. This junction can be seen exposed in the open about 2 miles from Bacup, at the top of Gorply Clough,

The united beds appear to run nearly N. and S. for several miles, for they occur again at Wholaw Nook, just at the top end of Clow Bridge Reservoir, on Burnley Moor.

After the union, the vegetable fossils disappear that were so numerous before, and the limestone nodules, full of marine fossils as before, are found on the top of the 5 feet seam just as they had previously occurred on the top of the Upper Foot. This, I think, is sufficient proof that the two coals do come together, for we never find them on the Gannister before it becomes 5 feet coal.

This Gannister seam of coal is worked at several places around Bacup, and is considered a very good coal.

A large quantity of fossil plants is found on the top of this coal, viz., *Ferns, Sigillaria, Lepidodendron, Ulodendron*, &c.

14.—Underneath the coal there is generally about 6 to 12 feet of fireclay and Gannister rock, which are always full of rootlets.

15.—Six feet of black shale.

16.—Nine feet of very fine Micaceous rock; only in one place have I seen this absent, viz., in Oaken Clough.

17.—Eight inches of very good Coal, called the *Lower Foot*; under this there is generally 2 to 4 feet of fireclay.

18.—Thirty-six to forty-six feet of dark shale.

These shale beds vary very much in thickness, even within short distances.

About the middle of this shale may be found, at some places, a large number of nodules, full of the shells of

Modiolopsis, not crushed, but in their natural shape, as at Grime Bridge Clough, near Lumb or Water.

About 10 feet below, there is another very extensive bed, larger than the above, but with the shells, *Anthracosia*, generally crushed, can be found at Oaken Clough, and several other places.

I found this bed at Helpit Edge, Saddleworth, during the Society's excursion last year.

19–20.—Two feet of inferior Coal, called in this district, Bassey Mine. It is identical with the Lower Yard Mine, of Saddleworth; it appears to be a very fair coal at Saddleworth, but in Rossendale it is very poor.

It is interspersed with bands of shale, perhaps a quarter of an inch of coal, and then quarter of an inch of shale, and so on, through the whole thickness of the bed. There is, generally, 2 feet of fireclay under it.

21.—Six feet of shale which contains a few fossil Ferns and Calamites.

22.—Twenty-four feet of fine grain sand-rock generally called Woodhead Hill Rock. This when well developed is a very fair building stone. Some little of it has been got almost in the town of Bacup, on the left hand side of Burnley road.

23-24.—Thirty-six feet of brown Shale and then 50 feet of black Shale.

About 15 feet from the bottom of the latter is a bed of fossil shells, partly casts, which present a curious appearance.

The fossil has been determined as *Myalina crassa var. modioliformis.*

These are found as a thickly compacted mass in a *stone row*, about 2 feet thick and naturally containing a quantity of lime from being so full of shells.

I have only found this fossil bed at Trough Gate or Britannia Station, on the Bacup and Rochdale Railway (about 1¼ miles from Bacup). I have searched the same

strata in several places, but have not been able to find the least trace of them.

I should never have got to see them at Trough Gate if the railway had not happened to cut through the bed which contained them.

These fossils were found in the first foot from the top of the *stone row*, and in the lower portion was another very small shell from quarter to half inch long, having a yellowish and smooth surface; but these I gave away and have not been able to procure other specimens since.

25-26.—Ten inches of Coal seen on Bramwood Moor, near Stacksteads, just above Brierley's coal pit. It has got the shale above and a fire-clay underneath, the latter being 18 to 24 inches thick, and is ground to make into bricks.

I have seen this coal cut through in two places, one at Shawforth in the turnpike road when making the road to the station, the other on the top of the hill going over to Britannia quarry.

About 18 inches above the small coal is a bed of fossils with abundance of *Goniatites, Pectens, Posidonomya Gibsoni, Lingula squamiformis*, best seen in Green's Clough and Tower's Clough.

27.—Under the small coal fire-clay there is 50 feet of rough sand-rock termed the Upper Rough Rock. It varies in the valley of Rossendale from 16 to 60 feet in thickness.

28.—Fourteen inches of coal, Feather-edge. Sometimes there is 1 to 2 feet of shale on the top, and when this occurs, the shale is full of fossil plants, ferns, &c.

This coal is worked by several people in this district at the present time.

It is a very fair coal where it has got plenty of weight on the top of it; where got at the outcrop is very poor. It has, generally, 3 feet of fireclay underneath.

29.—Twenty-four to thirty-four feet of sand-rock, called Lower Rough Rock.

The two beds, Upper and Lower Rough Rock taken together, are known by the name of Feather Edge, and constitute, I believe, the first Millstone Grit of the Geological Survey.

The lower portion, under the coal, makes a very good building stone, and is worked at two places near Bacup, viz., Bank House and Lee Height, on the opposite side of the valley.

In 1886, borings were made at Shepherd's Mill, Burnley Road, top end of Bacup, through the Upper and Lower Rough Rock and the coal, which gave, together, a thickness of 96 feet to these beds, as shown by the accompanying section of borehole.

BOREHOLE AT SHEPHERD'S, BACUP.

14 yards of clay.
4 yards of rock.
9 yards of black shale.
1 foot of coal.
32 yards of strong grit rock.
7 yards of black shale.
5 feet of blue shale.

68 yards from top of well.

30.—Thirty feet of dark drab Shale; near to the bottom is a bed of very small fossil shells, *Modiola Macadami*.

This shell is best found at Bonfire Hill Quarry, Crawshaw Booth. I have also found it at Bacup, but the place is now built over; also at Green's Clough, near Portsmouth.

This shale thins out in some parts of this district, as at Holcombe, where it is only a few inches thick.

31.—Forty-four feet of rock, used for flags, kerbstones, and setts; it is a very good hard stone, almost equal to granite, and is worked very extensively at the Crag and Britannia Quarries.

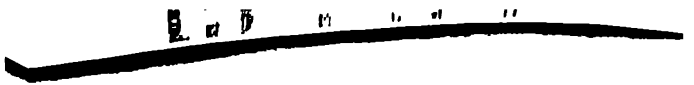

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Fig 4

Fig. 3

Fig. 1

Fig. 2

Fossil ferns are found occasionally in it.

32.—One hundred and thirty feet of brown and drab shale, exceedingly barren of fossils. At some places there is scarcely a trace of a stone in it. May be seen at Harescar, near Foe Edge.

33.—Twenty feet of black shale.

In the lower portion is a bed of fossils, *Goniatites Listeri*, *Pectens*, the shells being crushed and decayed. Goniatites and Pectens are very much crushed. May be found at several places in the district, among others at Horncliff, Great Height, Chapel Hill and Crawshaw Booth. Some very white mineral substance like alum crystallizes out of this shale when dry.

34.—Twenty feet of strong brown Shale.

35.—Twenty-seven feet of rock, known as the Haslingden Flag Rock, used for flags, kerb-stones, and setts, for which it is well adapted and is extensively worked at Hutch Bank and at Haslingden. Remains of *Calamites*, *Sigillaria*, and *Ferns*, are found in it.

36.—Thirty-three feet of brown and drab Shale; this bed varies very much in thickness, at Great Height it is 33 feet, but at Stacksteads it is only 2 feet thick.

Where these great differences occur, I generally find there is a great fault between, but why these faults should make such a difference I am at a loss to know. For in some cases that I know of there are 60 feet of rock on the one side of the fault and only 30 feet on the other, yet there are features in the top portion which show me that both sides of the fault belong to one and the same bed.

37.—Forty-four feet of rock, ripple marked, worked for flags, kerb-stones, and setts.

Cordaites borassifolius, *vide* Fig. 2, Plate I. (Elton Bank, Edenfield), and unnamed plant Fig. 3, Brow Edge Quarry, Great Height.

All these flag beds produce *ashlar*, *landing*, and *longstone*.

The two last beds of rock I take to be the No. 2 Millstone Grit.

38.—Ninety-eight ft. of brown and drab, very strong Shale.

This can best be seen at Thrutch, near Waterfoot, on the banks of the Irwell, where the river has cut its way through this rock. I have not found any fossils in the above.

39.—Thirty-five feet of black Shale.

About 20 feet from the bottom of this shale may be found a bed of fossils consisting of *Goniatites Listeri*, *Pectens*, *Posidonomya*, *Orthoceras*. May be seen at Cribden Clough, Holt Mill, Waterfoot, Coupe, and other places.

40.—Fifteen inches of Coal of a rather inferior quality, but is not now worked anywhere in the district; it has been tried once or twice but has been given up. There are several boreholes put down to this coal in and around Waterfoot for water, of which it appears to make a large quantity.

This is the top coal of the Brooksbottom series, and can be seen at Hallcarr, Hurdles, Coupe, and elsewhere.

41.—Forty feet of Micaceous Shale, unfossiliferous.

42.—Twenty feet very hard and fine-grained Sand-rock can be seen at Underwood, near Cloughfold; and at Holdenwood, near Helmshore, under the embankment of the reservoir.

43.—A small coal, 16 inches thick, at Holdenwood. At Underwood, near Cloughfold, it is divided into two thin bands. A pit was sunk to this coal in Horncliffwood, but no coal has been got for the last 40 years.

44.—Sixteen feet of rocky bands.

45.—Nine inches of black rock.

46.— One hundred feet of shale; the lower portion is very black. About 6 feet from the bottom there is a bed of fossils containing *Goniatites bilinguis*, *Posidonomya Gibsoni*, *Aviculopecten papyraceus*. Can be best found at Buckden Clough, between Holcombe Hill and Bull Hill. Above

this fossil bed is another, containing *Productus Flemingii, (Chonetes Laguessiana,= C. Hardrensis ?,)* near bottom of Tower's Clough, Portsmouth, Todmorden; in upper part are fine casts of large worm tracks.

47.—Three feet of black rock at Hallcarr, near Rawtenstall. At Buckden Clough it is 6 feet thick, where it has been mined for the repair of roads.

Close under this rock, at Buckden Clough, 6 inches of good coal occurs, but at Hallcarr, near Rawtenstall, no coal is found, but at both places a bed of good fireclay, 3 feet thick, is present.

48.—Fifteen to forty feet of a kind of drab Shale. At Hallcarr this bed is only 15 feet thick, whilst at Sunny Bank, Helmshore, near to Mr. Porritt's woollen mill, it is 40 ft.

Two beds of fossils occur in this shale, one about 10 feet from the top, may be seen on the north-east side of the river, a little above Mr. Porritt's mill, containing *Goniatites bilinguis, Pectene, Posidonomya, Productus scabriculus,* the last one rare, as I have only found it on one occasion. *Spines of Productus (?).*

The other fossiliferous bed is about 6 or 8 feet from the bottom of the 40 feet shale, and can be found at the lower end of Mr. Porritt's works, on the west side.

The fossils are in nodules, which contain the casts, in a decayed condition, of Goniatites; the shell substance is entirely gone, leaving only markings of the outer shell. Ferns and vegetable markings are also found in the same nodules.

49.—Fifteen to twenty feet of rock produces a quantity of flags at Balladen, near Rawtenstall, where it is 15 feet thick. At Ravenshore, 20 feet.

50.—Twenty-four feet of very dark Shale at Ravenshore, this appears to be absent at Balladen.

51.—Five feet of false bedded Sand-rock at Ravenshore.

52.—Three feet 6 inches blue Shale.

This bed is widely known as containing a large quantity

of fossil ferns, a fossil fruit, probably Rhabdocarpus multistriatus, (St.) has been found at Ravenshore, *vide* Fig. 4, Plate I.

53.—Under this shale at Ravenshore, 3 inches of coal occurs and then six inches of seating (a kind of fire-clay).

54.—Sixty feet of Sand-rock, rather false bedded; may be seen at Balladen, near Rawtenstall, it is not worked to my knowledge anywhere.

Full in places of plant remains, *Calamites*, &c.

55.—Thirty feet of brown Shale.

56.—Quarter of an inch of Coal, this can be seen at Carthouse quarry, Hall Hill, near Rawtenstall, and at Pigslee in Shuttleworth, in a quarry close to the turnpike road. The two localities being about 2 miles apart.

57.—Ten feet of very strong raggy Shale.

58.—Twenty-seven feet of very good sound Sand-rock makes very good *Ashlar*, can be seen at Carthouse quarry.

59-60.—Five feet of Shale, at the bottom of which there is a small coal about 6 inches thick, was formerly to be seen at Carthouse quarry but is now covered up, but it can be seen at the before mentioned quarry at Pigslee.

61.—Forty-two feet of Sand-rock, this is a very good building stone for *Ashlar* and all kinds of *Longstone;* it is very extensively worked at Fletcher Bank, near Ramsbottom, and can be seen in the railway cutting at Newhall Hey, Rawtenstall.

62.—About 4 feet of Shale may be seen under the above rock at Newhall Hey, which is the lowest stratum I have been able to see in this district.

(The three last beds of 27 feet of sand-rock, 5 feet of shale, and 42 feet of sand-rock, I think are Professor Hull's 4th Grit rock).

Mr. STIRRUP, during the reading of the paper, pointed out the special fossils on the table, which belonged to the different beds referred to; and said that although these fossils were fairly representative, they were by no means to

be considered as a complete series, Mr. Dugdale having from time to time given many of his specimens away.

The Millstone Grit series of rocks was generally regarded as unfossiliferous, but diligent search among the intercalated shales proves them to be otherwise, as shown by the numerous fossils exhibited.

These sandrocks, with their intervening shales, marked the different conditions under which they were respectively deposited, the former containing the remains of land plants, *Ferns, Calamites, Sigillaria, &c.*, while the shales contain a marine fauna of well known carboniferous types, as *Orthoceras, Goniatites, Productus, Lingula, Aviculopecten, &c.*

In some of these we have the survivors of a fauna which attained its fullest development in the seas of the carboniferous limestone, but the large size to which the Goniatites Listeri attained during a portion of the epoch of the Lower Coal Measures shows that the conditions for its existence still continued extremely favourable.

Mr. Stirrup called attention to the fossil fruit known as Rhabdocarpus, also to a well preserved leaf of what is known as *Cordaites borassifolius. Ung.*, a genus of uncertain affinity, which by its form looks very much like the Yucca, and which he believed to be rare in the Manchester coal-field, although it occurs elsewhere in England. Sir J. Wm. Dawson, in his Acadian Geology, speaks of it as common in Nova Scotian coal measures, while in the coal-fields of central France it is also a well known and main constituent of their upper coal beds.

GRANITE BOULDER AND FOSSIL PLANT FROM THE GANNISTER COAL, BACUP.

A granite boulder and fossil plant, sent by Mr. H. H. Bolton, from the Gannister coal at Bacup, were exhibited.

Mr. STIRRUP, referring to these specimens, said that he was in the Bacup district a fortnight ago, and happened to

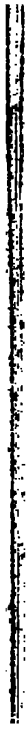
hear of this fossil which had been found by Mr. Lord, one of Mr. Bolton's managers. It not being one of the common vegetable forms found in the coal beds, he had requested Mr. Bolton to submit it to the inspection of the members at this meeting, and he had kindly done so. It appeared like one of the things figured in days gone by, under the name of *Palmacites*—(*vide* Plate II.) being very much like the outline of a palm leaf, but it was not recognised now that there were any fossil palms which could be certified as having lived during the deposition of the coal measures; and he was rather under the impression that it belonged to some other well-known families that occur in the coal, but to give a name or say anything more about it he did not feel justified at present.* The boulder upon the table was from the Gannister Mine at Bacup, and the memorandum he had with it was as follows:—"Found imbedded in the roof, close to the top of the coal, in the Old Meadow Pit;" and the fossil was found in the same mine—the Gannister Mine. The boulder, in its exterior, did not differ much from those which Mr. Radcliffe and other members had exhibited at former meetings, but he thought its composition would be seen to be somewhat different from those quartzite boulders which they had before seen, and in that respect it was very interesting.

Mr. RADCLIFFE, for the purpose of comparison, exhibited one of the ordinary quartzite boulders.

Mr. STIRRUP said these quartzite boulders were, as a rule, more plentiful in the Middle Coal Measures than in the Gannister. He believed the occurrence of boulders in the Gannister Mine was brought under the notice of the Society some years ago, before he (Mr. Stirrup) became connected with it. One or two instances were recorded in the Transactions. He hoped they would be able, after a microscopic examination, to know something more about Mr. Bolton's

* This fossil has since being submitted to the inspection of Professor Williamson, who identifies it as a terminal bunch of leaves of a species of *Cordaites*.

OLD MEADOW PIT
BACUP



granite specimen. These boulders were extremely interesting, and it was at present impossible to say how they got into the position in which they were found. Various suggestions had been thrown out to account for them, but none, as yet, was satisfactory. One theory was that during the deposition of the coal there was an ice period, when the boulders were transported from a distance, but of this there was no satisfactory evidence. They were evidently, however, far-travelled blocks, but no one yet has been able to say from what parent rock they had been derived.

NEW ELECTRIC LAMP ADAPTED FOR MINING PURPOSES.

Mr. J. S. Burrows exhibited a portable electric lamp of the Edison Company's manufacture, adapted for mining purposes. He said he must apologise for not having much to say with reference to this lamp, but he thought it desirable, inasmuch as this was the last meeting of the session, to bring it under the notice of the members at once, rather than wait for three or four months. Mr. Williamson, the manager of the Edison Company, had brought two lamps for inspection. He (Mr. Burrows) had used the larger of these lamps for two or three hours one day, and the same length of time on other days,—sometimes missing a day—and he found that the light was good for twelve or thirteen hours. He believed if the lamp was continued in use, without intermission, it would last somewhat longer. The members had an opportunity of judging of the quality of the light; he could only compare it to that of the full moon on a frosty winter's night. It was as good as any four Marsaut lamps.

A Member asked what was the weight of the lamp.

Mr. Williamson replied that the weight of one was about 7½lbs. and of the other about 5lbs.

Mr. BURROWS: I have carried that (referring to the larger lamp), or one like it, into some of the working places, but never found any inconvenience from the weight of it. You can put it in any position, whereas an oil lamp requires to be suspended vertically at all times.

Mr. WILLIAMSON, in reply to a question, said the lamp would last about fourteen hours. The lamp was furnished with a switch, the object of which was to maintain the light at a regular pitch all through. They were having a lamp made rather differently from that now shown, in the fact that it would have a concave instead of a convex reflector, and a hemispherical glass instead of a flat one in front.

Mr. BURROWS: This lamp is just the Edison Company's idea, they can, of course, alter the arrangements of the light in order to suit anyone's requirements; but the shape of this lamp is very convenient. When it is placed at a distance of six yards the face is well illuminated, and that I think, is a safe distance, and one where the lamp is little liable to get broken.

A MEMBER inquired how they compared as to cost.

Mr. WILLIAMSON: The cost is a point on which we are hardly able to speak yet. The lamps we have constructed up to the present time have cost us a good deal, owing to their being made singly, and according to different patterns, but as soon as the pattern is settled, then we shall go fairly into the matter of cost and see what they can be supplied for by the thousand.

A MEMBER: What would they cost daily?

Mr. WILLIAMSON: Very little indeed, the fan engine of the colliery would do very well for driving the dynamo and charging the accumulators, or a great number of them could be charged at one time by an engine of say 10 or 12 horse power.

In answer to further questions Mr. WILLIAMSON said, that the cost of the installation would probably not exceed

£120 or £140. The chief thing would be the cost of the lamps.

Mr. BURROWS: A point I would like to ask Mr. Williamson is this: One item of expense, I take it, would be the renewing of the carbon filament. Each filament lasts, I understand about 400 hours: that means about 6d. a week.

Mr. WILLIAMSON: The breakage of the filament means a new globe.

Mr. BURROWS: But that could not be much, it would just be about the cost of an oil lamp. But would the accumulator last any length of time?

Mr. WILLIAMSON: We have not yet had sufficient experience of that, we think they would.

Mr. RADCLIFFE: If the lamp should be knocked against a wall would it not break the filament?

Mr. WILLIAMSON: I think not. It is true that a constant vibration, as in railway trains, has a tendency to break the filament. But I do not think the occasional knocks a lamp would get in a mine could have that effect.

Mr. BURROWS: One thing struck me forcibly in using the lamp, that is, the light is so much superior that you no more think of knocking yourself, or the lamp either, against the sides, than you would think of doing so in walking about the streets. We have been long used to walking through the mine with a dim lamp, but this one gives a light like bright moonlight, and there is a wonderful difference in the ease of walking.

The CHAIRMAN asked if Mr. Williamson could give any approximate estimate of the cost of the lamp.

Mr. WILLIAMSON: They might ultimately be supplied—speaking roughly—at about 40s. But we could not supply one now at a less cost than £3.

Several gentlemen remarked that this would be a serious expense as compared with the cost of the oil lamps.

In the course of further conversation, Mr. BURROWS said that one of the chief difficulties in exploring a mine was that in the event of their entering an atmosphere charged with gas, the men's lamps went out, and they had to grope in the dark. This lamp, however, would enable a dozen explorers to penetrate anywhere.

The CHAIRMAN enquired as to the cost of renewal of the carbon filament.

Mr. WILLIAMSON: The cost of renewing the filament means the cost of putting in a new globe. They are 5s. each singly. In the ordinary way we average their life at 1000 hours each; and in these small lamps, with the rough usage they would get in the pit, that figure is about as much as we could reasonably expect. As a matter of fact, in our installation at the Theatre Royal, we had lamps which ran 2000 or 3000 hours. Those were of sixteen candle power.

The CHAIRMAN enquired how would that compare with the lighting of railway carriages.

Mr. WILLIAMSON: I made some experiments on the London, Brighton, and the South Coast line, and at first had a difficulty, but by arranging the lamps in a holder which was in itself a spring, got them to work quite well. In the first instance they were fixed rigidly to the compartment, and the difficulty was in the filament creaking.

Mr. BURROWS: Are not these on a spring?

Mr. WILLIAMSON: They are on a spring, and I think they would stand a great deal of vibration.

Mr. BURROWS said that to carry one of these lamps was quite a new experience in pit work. Some of his men were so pleased with it that—of course, without any idea of the cost—they said they would buy it for their own use. For his own part he should never again use an oil lamp so long as he could have one of these.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

[ANCHESTER GEOLOGICAL SOCIETY.

rt XI. Vol. XIX. Session 1887-8.

The Annual Meeting of the Members was held Tuesday, October 4th, 1887, at the Rooms of the nchester Literary and Philosophical Society, George reet,

Mr. Joseph Dickinson, F.G.S., Vice-President, in the Chair.

A letter was read from the President, Professor W. Boyd-awkins, explaining his inability to attend.

The Chairman then called upon the Hon. Secretary, Mr. ark Stirrup, to read the report of the Council for the st year:—

REPORT OF THE COUNCIL

For Session 1886-87.

Your Council have again the pleasure to report that the ciety continues in a sound and prosperous condition.

The number of the members on the register, though ffering from the unavoidable change wrought by death d removal, is increased by five.

Seventeen new members have been elected during the ar, two of whom have compounded for their subscriptions, d have become life members, while eight have resigned.

The Council regret the loss by death of five members, one whom, the Earl of Enniskillen, has been connected with

the Society as an honorary member since its foundation in 1838.

The list now stands as follows :—

Honorary Members	.. ..	17
Life „	.. ..	9
Ordinary „	.. ..	194
Total	.. ..	220

The usual number of meetings has been held, including two in the Mining School, Wigan, and an extra Evening Meeting in the Museum Room of the Owens College, as in the two previous years.

The purpose of the Evening Meetings at the Owens College has been to bring the members together in a less formal manner than at the ordinary meetings, and also with the further intention of inducing the members to take an intelligent advantage of the contents of a Museum with which the Society is so closely identified.

The new Museum is now being rapidly prepared for the various collections which have been so long waiting for the requisite space necessary for their installation and adequate exhibition.

It is hoped that during the current Session the members will have the opportunity of meeting in the new building, and thus after several years of anxious expectation, they will see the conditions fulfilled that accompanied the gift of the Society's geological collections to the authorities of the Owens College.

Several important papers have been contributed and published in the "Transactions" during the past year, of which a list is appended.

Those on local geology are, for the most part, the result of practical experience, and therefore merit careful attention, as a record of well-ascertained facts; while those on mining subjects testify to the increased care and scientific supervision that are being exercised in the working of the collieries of the district.

Many improvements have been made in the miner's safety lamp, of which various types have been recently

brought before you, and the adaptation of the electric light for underground mining operations, as exhibited at the closing meeting of the previous Session, would seem to point to the probable introduction in the near future of a portable electric lamp at a reasonable price, possessing the manifest advantage of a greater illuminating power, and increased safety to the miner.

On two occasions during the year, viz., on April 29 and May 2, Mr. Herbert Fletcher gave facilities to the members to inspect the workings and appliances at Lady Shore Colliery, and many gladly made use of the opportunity thus afforded.

On Saturday afternoon, 23rd July, a very successful excursion was made to Dulesgate, Todmorden, under the able leadership of Mr. Robert Law, F.G.S., in order to examine the MILLSTONE GRIT and LOWER COAL MEASURE rocks, which are well represented there.

Your Council have to acknowledge the kindness and courtesy of Sir Lowthian Bell and the Council of the North of England Institute of Mining and Mechanical Engineers in inviting the members, in conjunction with those of other similar societies, to a reception in the Industrial Exhibition building at Newcastle-upon-Tyne, on the 3rd of August.

Several members accepted the invitation, and availed themselves also of the opportunity which was offered of visiting some of the mines and manufactories of Tyneside, under the conductorship of the members of the Institute.

The Library still continues to receive large annual additions by exchange, presentation, and purchase, for which additional accommodation will soon be required. Attention has been previously drawn to the necessity of binding some of the serial publications which incommode the shelves, and for this purpose a grant of £25 has been allotted by the Council, but owing to the press of other matters upon your Secretaries, the requirements of the Library have had to stand over, and the money has not as yet been called for.

Among donations to the Library during the year may be mentioned a parcel of books from W. Whitaker, Esq., F.G.S., of the Geological Survey, and from the Council of

the British Association a copy of the Report of the meeting last year at Birmingham, to which the Society is entitled as one of the Corresponding Societies of the Association.

The following purchases among others have been made, viz. :—

The Origin of Mountain Ranges, by T. M. Reade.
Exposions in Coal Mines, by W. N. & J. B. Atkinson.
The Yorkshire Coal Field (Geological Survey Memoir).
Catalogue Illustré des Coquilles Fossiles, by M. Cossmann.
The Official Year Book of Scientific and Learned Societies of Great Britain and Ireland, 1887.
Lectures on Mining, by J. Callon, 3rd Vol. and Atlas.

The yearly Balance Sheet furnished by our Honorary Treasurer, Mr. Ormerod, shows a satisfactory state of the finances. The total receipts from all sources being £235 2s. 4d., and the total expenditure £144 1s. 6d., leaving a balance of £91 0s. 10d., which with the balance brought forward from the previous year of £6 14s. 3d. leaves a total balance of £97 15s. 1d. in favour of the Society.

As one of the Corresponding Societies of the British Association, it has been thought desirable that our Society should take up some definite work in connection with one or other of the Committees that are appointed by the Association to carry out scientific investigations.

To this end a few of the members have undertaken to collect information of the presence and mode of occurrence in their own neighbourhoods of those erratic blocks or boulders which are so frequent both in the plains and on the hill tops of many parts of Lancashire and adjoining counties. Any members who are willing to aid in this enquiry may obtain further information from the Secretaries, and also one of the printed forms of queries to which the Boulder Committee desire answers.

Other enquiries undertaken by British Association Committees might probably be assisted by other members, such as those relating to the circulation of underground waters in connection with the water supply of towns, and the rate of increase of underground temperature in mines.

The systematic investigation of the Carboniferous Flora and Fauna of the district might well be added to the list, and no better occasion could offer itself for a beginning than the present one, after the stimulus of the recent meeting of the British Association in our city.

The Council desire to remind the members that next year (1888) will be the fiftieth year of the existence of the Society, and it will be for them and the incoming Council to consider in what way the Society shall celebrate its Jubilee.

In conclusion, the Council hope that the Society will increase in vigour and efficiency, and that each individual member will take a personal interest in its work, and endeavour to promote its success and usefulness, not only by an increase of the number of members, but by contributing short communications or papers for discussion, so as to render the meetings as instructive and profitable as possible.

Mr. STIRRUP read the Statement of the Treasurer's Accounts:—

GENERAL STATEMENT.

	£	s.	d.		£	s.	d.
To Members as per last Account, Sept., 1886 ..	195	0	0	By Amount received year ending September, 1887 ..	182	10	0
,, New Members, 13 of £1, 3 of 10s. (half-year) ..	14	10	0	,, 6 Members discontinued	8	0	0
,, Arrears	28	0	0	,, 1 Member written off as bad	4	0	0
				,, 1 Member elected an Honorary Member	1	0	0
				,, Arrears	42	0	0
	£237	10	0		£237	10	0

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

1886-7	Abstract of Receipts.	£	s.	d.
Oct. 1.—To	Balance brought down, 1886	6	14	3
,,	Birkenhead Dividends.....	23	4	6
,,	Lancashire and Yorkshire Dividends	11	12	3
,,	Sale of Transactions.....	7	6	0
,,	Subscriptions, 1886-7	174	0	0
,,	Arrears	7	0	0
,,	New Half-Year Subscriptions ..	1	10	0
,,	Bank Interest.....	0	9	7
,,	Composition Life-Member, Sir H. F. de Trafford.....	10	0	0
,,	Do. Guy Wood	10	0	0
		£251	16	7
	To Balance brought down.....	£97	15	1

1886-7	Abstract of Payments.	£	s.	d.
Oct. 1.—By	Library	7	2	9
,,	Manuscript Catalogue of Library	10	0	0
,,	Transactions	53	15	1
,,	Reporter.....	12	17	0
,,	Circulars, Stationery, &c.	9	0	9
,,	Postages and Carriage of Parcels	16	19	2
,,	Meetings—Extra Expenses	1	11	9
,,	Collectors' Commission	9	12	6
,,	Rent, &c.	30	0	0
,,	Attendance	2	10	0
,,	Insurance	0	12	6
		£154	1	6
,,	Balance	97	15	1
		£251	16	7

The Investments consists of £600 Four per Cent. Guaranteed Stock of the Birkenhead Railway, and £300 Lancashire and Yorkshire Consolidated Four per Cent. Preference Stock, in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct, November 1st, 1887,
ALFRED PILKINGTON,
JAMES ATHERTON, } Auditors.

HENRY M. ORM...
1st October, 188...

e Treasurer's Balance Sheet as appended being read, s moved, seconded and carried unanimously that the t of the Council and the Treasurer's statement now be approved and adopted.

?OLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1886-7.

86.

er. Stirrup, Mark, F.G.S. British Association Meeting, Birmingham. Delegate's Report.

mber. Dawkins, W. B., M.A., F.G.S. President's Address. "On the Geography of Britain in the Carboniferous Period."

Watts, William, F.G.S. "Geological Sketches at Piethorn and Denshaw."

nber. Woodward, Herbert A. "Notes on Outbursts of Gas in the Mines at the Clifton, Kersley, and Newtown Collieries."

Burnett, R. T., F.G.S. "The Question of the Pre-Atlantic Land."

87.

ry. Stirrup, Mark, F.G.S. "On the Influence of the Changes of Atmospheric Pressure in the Development of Fire Damp."

Mercier, M. "Dust in Mines."

Hall, Henry. "A New Safety Lamp."

ary. Stirrup, Mark, F.G.S. "Fall of Roof in a Mine at Little Lever."

Kinahan, G. H., M.R.I.A. "Extent of the Carboniferous Sea as regards Ireland."

Kinahan, G. H., M.R.I.A. "On Marsh (Natural) Gas."

Kendall, Percy F. "The Carboniferous Volcanoes of Great Britain." (Given at Owens College.)

1. Ward, Thomas. "On the Subsidences in the Salt Districts of Cheshire: their History and Cause."

Hollingworth, G. H. "On Hunter Spencer's Watertight Cartridge Cases."

Duxbury, William. "The Argus Safety Lamp."

Stirrup, Mark, F.G.S. "The Cambassédès Lamp."

April, 1887. Thew, George. "A Gauzeless Safety Lamp."
Dickinson, Joseph, F.G.S. "Lamp Testing atus."
May. Mercier, M. "Dust in Mines."
June. Stirrup, Mark, F.G.S. "The Utilization of or Natural Gas."
Dugdale, Crispin. "On the Lower Coal M and Millstone Grit Rocks in the Forest of dale, with Remarks on some of the Fossil Beds contained therein."
Stirrup, Mark, F.G.S. "On a Granite Bould Fossil Plant from the Gannister Coal, Bacu
Burrows, J. S. "New Electric Lamp adap Mining Purposes."

NEW ORDINARY MEMBERS.

Boole, George
Bramall, Henry
Campbell, W. M.
Chandley, Chas.
Hall, Alfred Daniel
Hughes, James
Jackson, Andrew
James, J. Stanley
Law, Robert, F.G.S.
Mc.Kinless, J.
Meadows, Christophe
Nield, John
Scott, Fred. W.
Speakman, Henry
Trafford, Sir H. F. de
Walkden, Richard
Wood, Guy

MEMBERS DECEASED.

Enniskillen, Earl of
Jackson, J.
Pennington, Rooke, I
Perrin, J. B., M.R.C.
Turton, John, Junr.

MEMBERS RESIGNED.

Burns, Thos.
Cunliffe, James
Duncan, Wm., M.D.
Heys, James
Hulton, W. W. B.
Nuttall, Thos.
Uttley, J. F.
Yates, T. M.

ELECTION OF OFFICERS.

The HON. SECRETARY said that according to the rules of the Society it was obligatory that two Vice-Presidents, and four Members of the Council who had attended the fewest number of meetings should retire; the names of the gentlemen coming under the operation of this rule being read, the election was proceeded with, and the following Officers and Council were declared duly elected for the ensuing year:—

President:

JOSEPH DICKINSON, F.G.S.

Vice-Presidents:

R. T. BURNETT, F.G.S.
GEORGE PEACE.
GEORGE WILD.
ROBERT WINSTANLEY.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S.
G. W ORMEROD, F.G.S.
ANDREW KNOWLES.
G. C. GREENWELL, F.G.S.
JOHN KNOWLES, M.Inst.C.E.
R. CLIFFORD SMITH, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. K. SHUTTLEWORTH, BART.
GEORGE GILROY, M.Inst.C.E.
EDWARD PILKINGTON, J.P.
H. M. ORMEROD, F.G.S.
PROFESSOR W. BOYD DAWKINS, M.A., F.R.S., F.G.S.

Hon. Treasurer:

HENRY MERE ORMEROD, F.G.S.

Hon. Secretaries:

MARK STIRRUP, F.G.S.
GEO. H. HOLLINGWORTH, F.G.S.

Other Members of the Council:

JAMES ATHERTON.
W. S. BARRETT.
HENRY BRAMALL, M.I.C.E.
JOHN S. BURROWS.
HENRY HALL, H.M.I.M.
C. E. NEWTON, C.E.
GEO. HENRY PEACE.
JAMES RADCLIFFE, F.G.S.
JOHN RIDYARD.
JAMES TONGE, F.G.S.
WM. WATTS, F.G.S.
H. A. WOODWARD.

Hon. Auditors:

ALFRED PILKINGTON.
CLEGG LIVESEY.

ON THE WORK OF THE SOCIETY.

The business of the Annual Meeting being concluded, Mr. STIRRUP said: Some few months ago, I received some forms of queries from the Rev. Dr. Crosskey, the Hon. Secretary of the Boulders' Committee of the British Association, to distribute amongst those members who might be likely to take an interest in the matter. Several forms were given out to gentlemen who promised to carry out the wishes of this Committee, and I believe some of them have already got together information, which I hope will be brought before us in the form of communications, or papers, and which will afterwards be forwarded to the Boulders' Committee of the British Association. In this way, I think, it may be made both interesting to members of this Society, as well as valuable to the Boulders' Committee, which will then condense all the information that may be furnished, and bring it to a focus. With regard to the other Committees mentioned in the Annual Report, dealing with the underground temperature of mines and the circulation of underground waters, I think that many of the members might assist in these enquiries, by gathering information which would be of interest, not only to this Society, but also to a much larger circle.

The CHAIRMAN: I may mention that the Committee of the Free Library at Northwich, are endeavouring to establish a Museum, and they will be very glad to receive donations of fossils from the Lancashire coal field. They have, as yet, no collection at all: therefore, almost anything will be acceptable. Gentlemen who are engaged in mines where fossils abound in the roofs and strata, will perhaps kindly bear this in mind.

Mr. STIRRUP: Perhaps the matter might be more formally introduced at another meeting. I may mention also that it s

desirable that the geological collections at Owens College should be made as complete as possible. We have now a building there which has been the great want of Manchester for many years, it will take some months, no doubt, to arrange the existing collections therein, but I feel sure much might yet be done to increase the number of the representative forms of the fauna and flora of our local coal measures rocks, and although we have a collection which is possibly unequalled anywhere in the provinces, yet, it cannot by any means said to be complete. There are valuable fossils in the hands of local Geologists—fossils which are simply being wasted where they are—and which I think might, with a little persuasion, be obtained for the Museum at Owens College. I hold that local Museums might and ought to be of the highest value as educational institutions, especially to industrial communities like our own. It, therefore, rests with the members of a Society like this, to aid in an endeavour to make these public collections as perfect and representative as possible.

The Annual Meeting then terminated.

APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1886–87.

Belfast Natural History and Philosophical Society.—Report and Proceedings for Session 1885-6. *From the Society.*

Belfast Natural History Society.—Proceedings, 1871–2 to 1873–4. *Presented by W. Whitaker, F.G.S.*

Cambridge.—21st Annual Report of Museums, &c., Syndicate.

The Earth History of the Remote Past. Pamphlet, by J. E. Marr.

Notes on the Geology of the Vale of Clwyd. Pamphlet, by T. Mc.K. Hughes.

On some Perched Blocks. Pamphlet, by T. Mc.K. Hughes.

On the Geology of Anglesey. Pamphlet, by T. Mc.K. Hughes.

Hippopotamus, from Barrington. Leaflet, by Philip Lake. *From Professor Hughes, Woodwardian Museum.*

Chester Society of Natural Science.—16th Annual Report. *From the Society.*

Chesterfield and Midland Counties Institution of Engineers.—Transactions. Part 4, Vol. XIII., Contents and Index; Parts 3-6, Vol. XV. Sections of Coal Measures, Part 7, Vol. XV.; Part 1, Vol. XVI. *From the Institution.*

Cornwall.—Transactions of the Royal Geological Society of. Part 1, Vol. XI. *From the Society.*

Cornwall.—Royal Institution of. Journal, Part 1, Vol. IX. *From the Council.*

Cornwall.—Mining Association and Institute of Cornwall. Transactions. Part 1, Vol. III. *From the Council.*

Dublin.—Royal Dublin Society.—

Scientific Proceedings. Parts 3-6, Vol. V.

Scientific Transactions. Vol. III., Series 2, Nos. 11-13. *From the Society.*

Dublin.—Irish Arenaceous Rocks and three other Pamphlets, by G. H. Kinahan. *From the Author.*

Edinburgh Royal Physical Society.—Proceedings, Session 1885-86. *From the Society.*

Edinburgh Geological Society.—Transactions. Part 2, Vol. V. *From the Society.*

Essex Field Club.—Transactions. Part 2, Vol. IV. *From the Club.*

Essex Naturalist. Nos. 1-8. *From Essex Field Club.*

Glasgow Natural History Society.—Proceedings and Transactions. Part 3, Vol. I. *From the Society.*

Glasgow.—Geological Society of Glasgow. Transactions. Part 1, Vol. VIII. Catalogue of Library, 1886. *From the Society.*

Hertfordshire Natural History Society and Field Club.—Transactions. Parts 1-6, Vol. IV. *From the Society.*

Leeds Philosophical and Literary Society.—Annual Report, 1886-7. *From the Society.*

Leeds Geological Association.—Transactions. Part 2, 1885-86. *From the Association.*

Leeds.—Yorkshire Naturalists' Union.—Transactions. Parts 1-9. *From the Committee.*

Leicester Literary and Philosophical Society.—Report of Council for 1886. Transactions. Part 1, 1886; Parts 2-3, 1887. *From the Society.*

Liverpool Geological Society.—Proceedings. Parts 2-3, Vol. V. *From the Society.*

Liverpool Geological Association. — Transactions. Vol. VI., 1885-86. *From the Association.*

Liverpool Science Students' Association.—Annual Report, 1885-6, 1886-7. *From the Association.*

Liverpool.—Base of Carboniferous Limestone and another Pamphlet, by Dr. Ricketts. *From the Author.*

London Geological Society.—Quarterly Journal. No. 168, Vol. XLII.; No. 170, Vol. XLIII. List of Fellows, November, 1886. *From the Society.*

London Geologists' Association.—Proceedings. Nos. 6-8, Vol. IX.; Nos. 1-2, Vol. X. *From the Association.*

London Geological Magazine.—Nos. 268-280. *Purchased.*

London.—Institution of Mechanical Engineers. — Proceedings. Nos. 3-4, 1886; Nos. 1-2, 1887. *From the Institution.*

London.—Iron and Steel Institute.—Journal. No. 2, 1886; No. 1, 1887. *From the Institute.*

London.—Palæontographical Society.—Vol. XL., 1886. *Purchased.*

London.—Royal Institution of Great Britain.—Proceedings. No. 80, Vol. XI., Part 3. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 247-250, Vol. XLI.; Parts 251-257, Vol. XLII. *From the Society.*

Manchester Association of Engineers.—Thirty-first Annual Report, 1886. President's Address, Pamphlet, and Four other Pamphlets. *From the Association.*

Manchester Field Naturalists' and Archæologists' Society.—Report and Proceedings 1886. *From the Society.*

Manchester Microscopical Society.—Transactions and Annual Report, 1886. *From the Society.*

Manchester Scientific Students' Association.—Report and Proceedings, 1885.

Midland Institute of Engineers.—Transactions. Parts 83-88, Vol. X.; Part 89, Vol. XI. *From the Council.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers.—Transactions. Part 4, Vol. XXXV.; Parts 1-3, Vol. XXXVI. *From the Institute.*

North Staffordshire Naturalists' Field Club.—Annual Report and Transactions, 1886. *From the Club.*

Scotland.—Mining Institute of Scotland.—Transactions. Parts 5-8, Vol. VIII. Parts 1-4, Vol. IX. Glossary of Scotch Mining Terms. *From the Council.*

South Wales Institute of Engineers.—Proceedings. Nos. 1-3, Vol. XV. *From the Institute.*

Stirling Natural History and Archæological Society.—Transactions. 1885-86. *From the Society.*

Yorkshire Geological and Polytechnic Society.—Proceedings. Part 2, Vol. IX., N.S. *From the Society.*

Official Year Book of Scientific and Learned Societies of Great Britain and Ireland, 1887. *Purchased.*

Explosions in Coal Mines. By W. N. and J. B. Atkinson. *Purchased.*

Special Report on Explosion of Fire Damp at Bedford Colliery, Lancashire. By Joseph Dickinson, F.G.S. *From the Author.*

Notes on "Cone in Cone Structure." Pamphlet by W. S. Gresley.

Origin of Mountain Ranges. By T. M. Reade. *Purchased.*

Geology of Yorkshire Coal Field. Survey Memoir. *Purchased.*

British Association Report. Birmingham Meeting, 1886. *Presented by the Association.*

Mining and Mineral Statistics of United Kingdom for Year 1886. *Presented by J. Dickinson, F.G.S.*

Lectures on Mining at School of Mines, Paris. Vol. III., and Atlas. By J. Callon. *Purchased.*

U.S.A.--Geological and Geographical Survey of the Territories: Bulletin, Nos. 2–6, Second Series; Bulletin, Vol IV., Nos. 1–4; Bulletin, Vol. V., Nos. 2–4. Catalogue of Publications, Geological and Geographical Survey. Sketch of Origin and Progress of Geological and Geographical Survey. Proceedings of Academy of Natural Sciences of Philadelphia, Part 3, 1878; Parts 1–3, 1879; Parts 1–3, 1880; Part 2, 1881. Six Pamphlets on Water Supply, &c., by W. Whitaker, F.G.S. One Pamphlet on Bournes, by H. H. French. Travels in the Tarentaise, by R. Bakewell; 2 Vols. Geological Pamphlets, by C. Prévost; 1 Vol. *Presented by W. Whitaker, F.G.S.*

Annual Reports, from the Committees.

Cambridge University.—Report of Library Syndicate, June, 1886.

Devon and Exeter Albert Memorial Museum.—17th Annual Report of Committee.

Liverpool Free Library and Museum.—34th Annual Report.

Manchester.—Owens College.—Calendar. 1887–8.

Oxford University Museum.—Catalogue, Radcliffe Library. 1886.

Salford Museum, Libraries, and Parks.—38th Annual Report. 1885–6.

Canada and U.S. America.

Canada.—Canadian Institute, Toronto.—Proceedings. Nos. 1–2, Vol. IV., 3rd Series. *From the Institute.*

Canada.—Geological Survey of Canada. Report of Progress for 1873–74.

Mesozoic Fossils. Vol. I. By J. F. Whiteaves, F.G.S.

Palæozoic Fossils. Vol. II., Part 1. By E. Billings.
,, ,, Vol. III., Part 1. By J. F. Whiteaves.
Map and Sections to accompany Annual Report, 1885.
From A. R. C. Selwyn, F.R.S., Director of the Survey.

Canada, Royal Society of.—Transactions. On the Fossil Plants of the Laramie Formation. By Sir J. W. Dawson. *From the Author.*

Canada.—Hamilton Association.—Journal and Proceedings. Part 2, Vol. I., 1884–5; Vol. II., 1885–6. *From the Association.*

Catalogue of Collection of Economic Minerals of Canada, Colonial and Indian Exhibition. 1886.

Canada.—Geological and Natural History Survey of Canada.—Annual Report, Vol. I., 1885.
Maps to accompany Annual Report, 1885.
From Dr. A. R. C. Selwyn.

U.S.A., Cambridge.—Harvard College.—Annual Report of the Curator of the Museum of Comparative Zoology. 1885–6. Bulletin of the Museum of Comparative Zoology. No. 6, Vol. XII. Report on Mollusca, Nos. 1–4, Vol. XIII. Reports on Results of Dredging. *From Alexander Agassiz.*

U.S.A., Columbus, Ohio.—Preliminary Report upon Petroleum and Inflammable Gas, with Supplement. By Edward Orton, State Geologist. *From the Author.*

U.S.A., Minnesota: The Geological and Natural History Survey of: 13th and 14th Annual Reports, 1884–5. *From N. H. Winchell.*

U.S.A., New York.—American Museum of Natural History. Bulletin No. 7, Vol. I. No. 1, Vol. II., Annual Report of the Trustees, 1886–7. Index to Vol. I., 1881–86. *From the Trustees.*

U.S.A., New York.—American Institute of Mining Engineers.—Transactions, Vol. XV. *From the Institute.*

U.S.A., Pennsylvania, Geological Survey of.—Annual Report, 1885. Atlas to accompany the above. *From J. P. Lesley, State Geologist.*

U.S.A., Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2–3, 1886. Part 1, 1887. *From the Academy.*

U.S.A., Philadelphia.—Journal of Franklin Institute. Nos. 730–741, Vol. CXXIII. *From the Institute.*

U.S.A., St. Louis.—Natural Gas in United States. Geological Relations of Nanticoke Disaster.—Pamphlets by C. A. Ashburner, C.E. *From Second Geological Survey, Pennsylvania.*

U.S.A., Washington.—Smithsonian Institution.—Annual Report, Part 1, 1885. *From the Board of Regents.*

U.S.A., Washington.—United States Geological Survey.
Geological History of Lake Lahontan, by J. C. Russell.
Monograph: Vol. X., Dinocerata, by O. C. Marsh.
Bulletin. Nos. 27–39. Index, Bulletin, Vol. IV.
Mineral Resources of United States, 1885. *From the Director of the Survey, J. W. Powell.*

U.S.A., Washington.—Report upon Third International Congress and Exhibition at Venice. *From Chief of Engineers, U.S. Army.*

AUSTRALASIA.

Melbourne.—Transactions of Geological Society of Australasia. Part 1, Vol. I. List of Members of Geological Society, 1886–7. *From the Society.*

New South Wales.—Annual Report of Department of Mines for 1885.

New Zealand.—Report of the Mining Industry of. 1886. *From the Government.*

Sydney, N.S.W.—Report of Trustees of Free Public Library, 1885–6.

Sydney.—Royal Society of New South Wales. Journal and Proceedings. 1885, Vol. XIX. *From the Society.*

Victoria.—Geology and Physical Geography of. By R. A. F. Murray.

Victoria.—Gold Fields of. Reports of Mining Registrars. June, 1886, to March, 1887. *From the Government.*

Victoria.—Mineral Statistics for 1885. *From the Government.*

Victoria.—Report of Trustees of the Public Library, Museum, &c., for 1885.

FOREIGN.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 3–4, Band XXXVIII. Band XXXIX., Heft 1, 1887. *From the Society.*

Brussels.—Société Royale Malacologique de Belgique. Annales. Vol. XXI. Procès-Verbaux, August to December, 1886, January to June, 1887, Tome XVI. *From the Society.*

Buenos Ayres.—Estadistica del Comercio y de la Navegacion de la Republica Argentina. 1885 and 1886. Procedimientos del Departamento Nacional de Estadistica, 1886. Arrendamiento de las Obras de Salubridad de la Capital. Discurso par E. Wilde. *From the Government.*

Dresden.—Sitzungsberichte der Naturwissenschaftlichen Gesellschaft Isis in Dresden. July to December, 1886, January to June, 1887. *From the Society.*

Halle, a/S.—Vereins fur Erdkunde. Mittheilungen, 1886. *From the Society.*

Halle.—Leopoldina; Vol. XXI. Leop. Carol. Deutschen Akademie der Naturforscher, Band XLVIII., No. 3. *From the Academy.*

Lausanne: Bulletin de la Société Vaudoise des Sciences Naturelles. Nos. 94–95, Vol. XXII. *From the Society.*

Liége.—Sur le Tufeau de Ciply. Pamphlet, by A. Rutot and E. Van den Broeck. *From the Authors.*

Lille.—Société Géologique du Nord. Annales XIII., 1885–6. *From the Society.*

Paris.—Revue de le Legislation des Mines. Monthly. *Purchased.*

Paris.—Catalogue Illustré des Coquilles Fossiles des Environs de Paris. by M. Cossman. Parts 1–2. *Purchased.*

Pisa.—Atti della Società Toscana di Scienze Naturali. Memorie. Fasc. 1, Vol. VIII., Processi Verbali, July, 1886, to July, 1887. *From the Society.*

Roma.—Atti della Reale Accademia dei Lincei. Memorie. Vol. I., 1884-85. Rendiconti. Fasc. 5-12, Vol. II.; Fasc. 1-13, Vol. III., 1st Semestre; Fasc. 1-3, Vol. III,. 2nd Semestre. *From the Academy.*

St. Petersbourg.—Academie Impériale des Sciences. Bulletin. Part 4, Tome XXX.; Parts 2-3, Tome XXXI. Memoires.

Tome XXXIV., Parts 4-13, No. 1, Tome XXXV. *From the Academy.*

Petersbourg. — Institut des Mines. Comité Géologique. Mémoires:

Vol. III., No. 2. Vol. IV., No. 1.

Bulletins: Nos. 7-11, 1886; Nos. 1-7, 1887, Vol. VI.

Supplément au Tome VI., Bibliothéque Géologique de la Russie.

Carte Géologique Génerale de la Russie d'Europe, Feuille 139. *From the Institute of Mines.*

ttettin.—Vereins für Erdkunde. Jahresbericht, 1886. *From the Society.*

BOOKS PURCHASED, 1886-7.

ological Magazine.

vue de la Legislation des Mines. Paris.

læontographical Society's Monograph. Vol. XL. 1886.

e Origin of Mountain Ranges. By T. M. Reade.

plosions in Coal Mines. By Atkinson.

e Yorkshire Coal Field (Geol. Survey Memoir).

talogue Illustré des Coquilles Fossiles. By M. Cossmann. Parts 1 and 2.

icial Year Book of Scientific and Learned Societies of Great Britain and Ireland, 1887.

ctures on Mining. By J. Callon. 3rd Vol. and Atlas.

SOCIETIES WITH WHOM THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHOM A COPY IS SENT FREE.

I.—ENGLAND.

London .....British Museum.

Geological Society, Burlington House.

Geological Survey, Jermyn Street, S.W.

Geologists' Association.

Institute of Mechanical Engineers, Victoria Street, S.W.

Iron and Steel Institute, Victoria Mansions, S.W.

Royal Institution.

London .....Royal Society, Burlington House.

Manchester .....The Manchester Association of Engineers, 18, Hullard Street, Old Trafford.

Field Naturalists' Society, 16, Kennedy Street.

Free Library, King Street.

Literary and Philosophical Society.

Owens College.

Salford Royal Museum and Library.

Scientific Students' Association, 36, George Street.

Barnsley .....Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.

South Staffordshire and East Worcestershire Institute of Mining Engineers, Burlington Chambers, New Street.

Bristol .....Naturalists' Society.

Cambridge .....Geological Museum, University.

University Library.

Chester .....Society of Natural Science.

Chesterfield.....Institute of Mining Engineers (in bound vols.)

Cornwall.....Royal Geological Society, Penzance.

Royal Institution, Truro.

Tuckingmill, Camborne ....Mining Association and Institute of Cornwall.

Essex .....Essex Field Club, 8, Knighton Villas, Buckhurst Hill, Essex.

Exeter.....Albert Memorial Museum.

Halifax .....Geological and Polytechnic Society of Yorkshire.

Leeds .....Philosophical and Literary Society.

Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Sunny Bank).

Leicester .....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.

Geological Association, Free Library, William Brown Street.

Geological Society.

Newcastle-on-Tyne.Institute of Mining and Mechanical Engineers.

Norwich .....Geological Society, Museum.

Oxford.....Bodleian Library.
Radcliffe Library.
North Shields....Public Free Library.
Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea .....South Wales Institute of Mining and Mechanical Engineers.
Warwick.....Natural History Society.
Watford, Herts...Natural History Society and Field Club.
Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee .....Free Library and Museum.
Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.
Glasgow .....Geological Society.
Natural History Society.
Hamilton .....Mining Institute of Scotland.

III.—Ireland.

Dublin.....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast.....Natural History Society, The Museum.

IV.—Australia.

Melbourne .....Geological Society of Australasia (Phœnix Chambers, Market Street).
Public Library of Victoria.
Sydney .....Free Public Library.
Royal Society of New South Wales.
Newcastle .....John Mackenzie, F.G.S.

V.—Canada.

Hamilton.....Hamilton Association.
Montreal.....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College (Principal, J. W. Dawson, F.G.S.)
Toronto .....Canadian Institute.

VI.—United States.

Boston, U.S. ....Free Library.
Columbus, U.S. ..Ohio, Geological Survey of (Professor Edward Orton, State Geologist.
Indiana, U.S......Department of Geology and Natural History (John Collett, State Geologist).
Indianopolis, U.S...E. T. Cox, State Geologist.
Newhaven, U.S....Professor O. C. Marsh, F.G.S.
New York, U.S....American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).
New York .....American Museum of Natural History, Central Park.
*Philadelphia, U.S.*Academy of Natural Sciences.
Franklin Institution.
Washington, U.S...Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.
Wyoming, U.S....Historical and Geological Society.

VII.—Foreign Societies.

Berlin.....Deutsche Geologische Gesellschaft.
Brussels .....Société Royale Malacologique de Belgique.
Buenos Ayres....Officiana Nacional de Commercie.
Calcutta .....Geological Survey of India.
Christiania.....Royal University of Norway.
Dresden .....Naturwissenschaftliche Gessellschaft Isis.
Halle, A.S. .....Verein fur Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.
Lausanne (*Suisse*)..Société Vaudoise des Scienes Naturelles.
Lille .....Société Géologique du Nord.
Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.
Rio de Janeiro ..Museo Nacional.
Rome .....Reale Accademia dei Lincei.
St. Petersburg....Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.
Turin .....Académie Royale.

VIII.—Scientific Journals, &c.

Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review, Revue de la Legislation des Mines, Paris. (M. Delecroix, 7, Place du Concert à Lille.)

PAST PRESIDENTS OF THE SOCIETY.

of Election.	
)-40	Egerton, The Rt. Hon. Francis, M.P.
):-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
)-5, 55-6-7	Egerton, Sir Philip de Malpas Grey-, Bart, M.P.
):-7	Mosley, Sir Oswald, Bart.
)-9	Thicknesse, Ralph, M.P., Wigan.
):-3	Black, James, M.D., F.G.S.
)-5	Ormerod, G. W., M.A., F.G.S.
)-9, 65-6-7	Binney, E.W., F.R.S., F.G.S.
):0-1	Kay-Shuttleworth, Sir J. P., Bart, M.P.
):-3, 77-8	Dickinson, Joseph, F.G.S.
)-5	Knowles, Andrew.
):-9, 84-5	Greenwell, G. C., F.G.S.
'0-1, 82-3	Aitken, John, F.G.S.
):-3	Knowles, John, M.Inst.C.E.
)	Knowles, Thomas, M.P.
):, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
):	Smith, R. Clifford, F.G.S.
)	Forbes, John Edward, F.G.S.
):0	Lindsay, Lord, F.R.S.
)	Kay-Shuttleworth, Sir Ughtred J., Bart.
):	Gilroy, George, M.Inst.C.E.
)	Pilkington, Edward, J.P.
):	Ormerod, Henry Mere, F.G.S.

LIST OF MEMBERS.

OCTOBER, 1887.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Withins Lane Colliery, Radcliffe.
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Rishton Colliery, Blackburn.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton. *Member of Coun*
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Ha Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1885	Barker, Israel, 319, Whit Lane, Pendleton.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpo *Member of Council.*
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Ma chester.
1877	Beswick, James, Shakerley Collieries, Tyldesley.
1885	Bickerton, Charles W., Hazel Grove, near Stockport.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Squa Edinburgh.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Baxenden, Accrington.
1887	Boole, George, Rainford Colliery, near St. Helens.
1878	Bradford, The Right Hon. the Earl of, Weston Park, Shifnal.

Year of Election.	
1886	Bramall, Henry, M.Inst.C.E., Pendlebury Colliery, Manchester. *Member of Council.*
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernst Van den*, 124, Rue Terre Neuve, Brussels.
1877	*Brongniart Charles*, F.E.S., 8, Rue Guy-de-la-Brosse, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm. Speakman, Summerby, 106, Eccles Old Road, Eccles.
1859	Bryham, William, J.P., Ince Hall, Wigan.
1881	Bryham, William, jun., Douglas Bank Colliery, Wigan.
1882	Burnett, R. T., F.G.S., 34, Belmont Street, Southport. *Vice-President.*
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Yew Tree House, Atherton, near Manchester. *Member of Council.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1887	Chandley, Charles, Latchford, Warrington.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1886	Clifford, William, Norton Woodseats, Sheffield.
1882	Cookson, Charles, King Street, Wigan.
1878	Cooke, Charles, Twycross, Atherstone, Leicestershire.
1859	*Coulthart, John Ross, F.R.S., Lit., F.S.A., Scot., Greenlaw Park, Castle Douglas, Kirkcudbrightshire, N.B.
1878	Cowburn, Henry, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.

Year of Election.	
1862	*Derby, The Right Hon. the Earl of, Knowsley, Liverpool.
1882	Devonport, John, Chamber Collieries, Oldham.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *President.*
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1885	Dugdale, Crispin, 5, North Road, Cloughfold, Rossendale.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Old Hall, near Manchester.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1873	Garforth, W. E., Colliery Offices, Normanton.
1884	Garside, Sampson, Denton and Houghton Collieries, Denton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy George, M.Inst.C.E., Woodlands, Parbold, Wigan. *Past-President.*
1882	Glover, B. B., Haydock, near St. Helens.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1882	Gresley, W., Stukeley, F.G.S., Overseal, Ashby-de-la-Zouch.
1863	Greenwell, G. C., F.G.S., Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, jun., Ashton Moss Colliery, Audenshaw, Manchester.
1879	Gregson, Edward, 11, Chapel Street, Preston.

Year of Election.	
1883	Greensmith, T., Moston Colliery, Failsworth, Manchester.
1880	Grimke, Theodore Drayton, Golborne Hall, Newton-le-Willows.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1879	*Guibal, Theophile,* Professeur d'Exploitation des Mines, Mons, Belgium.
1887	Hall, Alfred Daniel, Hulme Grammar School, Alexandra Park.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescott. *Member of Council.*
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester.
1880	Hargreaves, John, Collyhurst Paper Mills, Manchester.
1874	*Hawkshaw, Sir John,* Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.,* State Geologist, Washington, U.S.A.
1882	Heathcote, William, Farnworth, near Bolton.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester.
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1883	Hewitt, John R., Mining Engineer, Derby.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, Wigan Coal and Iron Company, Wigan.
1885	Hindley, C.E., Clifton Road, Eccles.
1878	Holden, Charles H., Mawdsley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester. *Hon. Secretary.*
1884	Howatt, Andrew, 25, Mill Street, Ancoats, Manchester.
1878	Howell, John, Astley, near Manchester.

Year of Election.	
1887	Hughes, James, Astley and Tyldesley Coal and Salt Co., Limited, Tyldesley.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester.
1880	Jackson, William, 75, Broadway Street, Oldham.
1887	James, J. Stanley, Surveyor, Atherton Collieries.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton.
1884	Johnson, M. G., Rainhill, Prescott.
1882	Johnson, William, Abram Colliery, Wigan.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1885	Kearsley, William, 115, Manchester Road, Tyldesley.
1882	Kenney, George, 11, King Street, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Ramilton, S.O., Donegal Ireland.
1856	Knowles, Andrew, Swinton Hall, Swinton, near Manchester *Past-President.*
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury *Past-President.*
1882	Knowles, Israel, Ince, Wigan.
1877	Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury
1886	Knowles, Robert, Arncliffe, Cheetham Hill.
1886	Law, Robert, F.G.S., 11, Cromwell Terrace, West Park, Halifax.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.

Year of Election.	
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Hon. Auditor.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 6, De Grey Road, Leeds.
1884	Lyon, Edward, Ashton's Green Collieries, St. Helens, Lancashire.
1884	McAdoo, John, Colliery Manager, Hagside, Radcliffe.
1881	McAlpine, G. W., Whinney Hill Colliery, Accrington.
1887	McKinless, J., 1, Gore Street, Greenheys, Manchester.
1873	*Martin Joseph S.*, F.G.S., H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1883	Mather, William Penn, Iron Works, Salford.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester.
1887	Meadows, Christopher, Ellerbeck Collieries, Limited, near Adlington, Lancashire.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1885	Newton, Charles Edward, C.E., Sale Bank Cottage, Sale. *Member of Council.*
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.
1886	Nield John, Longshut Lane, Stockport.
1838	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth. *Past-President.*
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester, *Hon. Treasurer and Past-President.*
1874	*Owen, Sir Richard*, D.C.L., F.R.S., Sheen Lodge, Richmond Park, London, S.W.

Year of Election.	
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1883	Peace, George Henry, Monton Grange, Eccles. *Mem of Council.*
1877	Peace, Maskell W., F.G.S., Wigan.
1881	Pearson, A., Dukinfield Cottage, near Ashton-under-Lyn
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manches *Hon. Auditor.*
1879	Pilkington, Charles, Ashton and Edge Green Collier St. Helens.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manches *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford
1887	Platt, Samuel Sydney, Assoc.M.Inst.C.E., Borough S veyor, Rochdale.
1867	Radcliffe, James, F.G.S., Astley Deep Pit, Dukinfield; 1 King Street, Dukinfield. *Member of Council.*
1874	*Ramsay, Sir A. C.*, LL.D., F.R.S., &c., 15, Crom Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton. *Member of Council.*
1882	Rigby, William, Leader's Buildings, King Street, Wig
1877	Robins, George J., Ashton, near Newton-le-Willows.
1884	Rogers, William, King Street, Wigan.
1884	Roscoe, James, Little Hulton, Bolton.
1882	Sacré, R. A., West Kirby, near Birkenhead.
1880	*Schofield, Christopher James, Whalley Villa, Whal Range, Manchester.
1887	Scott, Frederic W., Atlas Works, Reddish, near Stockp
1866	Selby, Atherton, Mining Engineer, Leigh
1882	Settle, Joel, Madeley Coal & Iron Co., Limited, Madel near Newcastle, Staffordshire.

Year of Election.	
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1884	Simpson, W. W., Church, Accrington.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	*Smethurst, William, F.G.S., 1, South John Street, Liverpool.
1838	Smith, G. F., M.A , F.G.S., Grovehurst, Tunbridge Wells.
1881	Smith, John, Bickershaw Collieries, Westleigh.
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1881	Squire, J. B., A.Inst.C.E., 1, Sibella Road, Clapham, London, S.W.
1859	Statter, Thomas, Stand Hall, Bnry.
	Stechert, G. E., 26, King William Street, Strand, London, W.C.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Hon. Secretary.*
1882	Stopford, T. R., Swan Lane Brick and Coal Company, Hindley Green, near Wigan.
1882	Storey, Edgar, Leigh, Lancashire.
1881	Taylor, Alfred, Norley Collieries, Wigan.
1880	Teale, William E., Fern Bank, Worsley.
1884	Toman, Daniel, Chamber Colliery, Oldham.
1877	Tomlinson Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton. *Member of Council.*
1876	Topping Walter, Bamfurlong Collieries, near Wigan.

Year of Election.	
1886	*Trafford, Sir Humphrey Francis De, Bart., Trafford P Manchester.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1887	Walkden, Richard, Colliery Manager, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, 11, King Street, Wigan.
1886	Wallwork, John, Clifton Moss Colliery, Clifton, Manche
1882	Wallwork, Thomas, Colliery Office, Walkden, near Bo
1879	Walshaw, John, Astley and Tyldesley Collieries, Tylde
1879	Warburton, William, High Lane, near Stockport.
1885	Ward, Thomas, Brookfield House, Northwich.
1880	Watts, William, F.G.S., Piethorne, Rochdale. *M of Council.*
1878	Wells, Samuel B., Mining Engineer to the Bengal Coa Ld., Khooldea Collieries, Giridih, India.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1884	Whitehead, John, Chorley, Lancashire.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Vice-President.*
1880	Williams, E. Leader, M.Inst.C.E., Queen's Chambers, Dalton Street, Manchester.
1886	*Williamson, Professor W. C.*, LL.D., F.R.S., Egerton Fallowfield.
1876	Winstanley, Robert, 28, Deansgate, Manchester. *Vice-President.*
1886	*Wood, Guy, 71, King Street, Manchester.
1876	Woodward, H. A., Clifton, near Manchester. *Memb Council.*

Members are requested to communicate to the Hon. Secretarie changes of address, also any corrections or omissions in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XIX. SESSION 1887-8.

The ORDINARY MEETING of the Members was held on Tuesday, November 1st, 1887, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOSEPH DICKINSON, F.G.S., &c., in the Chair.

NEW MEMBER.

Mr. WILLIAM SAINT, one of H.M. Inspectors of Mines, 24, George Street, Cheetham Hill, was balloted for, and unanimously elected an Ordinary member of the Society.

The PRESIDENT delivered the following address:—

THE PROGRESS OF MINING AND GEOLOGY.

An Outline.—Inaugural Address, 1st November, 1887.

BY JOSEPH DICKINSON.

Her Majesty's Senior Chief Inspector of Mines.
Fellow of the Geological Society of London.
Honorary Member, North of England Institute of Mining and Mechani Engineers.
Ditto. Royal Institution of Cornwall.
Ditto. South Staffordshire and East Worcestershire Insti of Mining Engineers.
Ditto. South Midland Institute of Mining, Civil, and Mechan Engineers.
Ditto. North Staffordshire Institute of Mining and Mechan Engineers.
Ditto. South Yorkshire Viewers' Association.
Ex-officio Honorary Member, Chesterfield and Derbyshire Institute of Min Civil, and Mechanical Engineers.
Ditto. ditto. Midland Institute of Mining, Civil, and M anical Engineers.

I have the pleasure of thanking the Society for the hon conferred in again electing me President.

It is the fourth time that such honour has been bestow on me, but on this occasion more than usual importanc attached. It is the Jubilee year in the reign of Her Maj the Queen, and also the Jubilee session of this Society.

The occasion seems one for a retrospective view.

Of the 194 members with which this Society began v few now survive. The ordinary members then consiste persons interested in various pursuits, geologists, min lessors of mines, mechanical engineers, manufactur bankers, lawyers and doctors.

Amongst the honorary members were those bearing immortal names of Louis Agassiz, Adolphe Brongni

Buckland, Dalton, De la Beche, Greenough, Lyell, Murchison, John Phillips, Sedgwick, Whewell. They, and also all the others are gone except Mr. T. W. Embleton, alone remaining.

The Society commenced with vigour. Some good papers were read. It gathered together a good geological museum. All went on well for a time. Meetings were held at the Natural History Society's Museum, in Peter Street. The force, however, declined. In 1857, Mr. Binney was elected President. Changes ensued. The Society revived. Subjects of interest were again introduced. Other members have followed on, and although the museum has been given to the Owens College, the Society has since prospered.

The two objects of this Society are geology and mining, and it is on the progress that has been made in these two subjects that I propose to offer an outline without further preface.

Geology.

It would be too elaborate to enter into detail of the early geological views. For these I may safely refer to Sir Charles Lyell's or other works on Geology, in which all that is needed in geology and also in cosmogony are given.

It will suffice for the present if I begin with a writer in the early part of the present century.

In 1813, Robert Bakewell in his "Introduction to Geology," says that till about the middle of last century the structure of the earth had scarcely engaged the attention of philosophers. Near that time Lehman, the German, observed that there are certain rocks which occupy the lowest relative position in different countries, and that these rocks contain no organic remains; hence was given the name of Primary, and a division established between them and the rocks by which they are covered in which fossil remains frequently occur; the latter were called Secondary.

Between these were shown Transition rocks, and over the Secondary were the newest deposits. Mr. Bakewell also says that in our own country the Rev. Mr. Mitchell, in a paper on the cause of earthquakes which appeared in the Philosophical Transactions, 1759, was the first person who appears to have had any clear views respecting the structure of the crust of the earth; and that about twenty years afterwards Mr. John Whitehurst published his inquiry into the original state and formation of the earth.

That till the beginning of the present century geological pursuits made little progress in England. On the continent the researches of Saussure, Pallas, Werner, St. Fond, Dolomieu and others, had before this time produced a powerful interest, and brought into the field many active and intelligent inquirers.

The first impulse given to the public taste for geological investigations in this country was produced by Professor Playfair's illustrations of the Plutonian Theory of Hutton. The leading feature of this theory being, that all rocks or strata have been formed or consolidated by central subterranean fire, which was ably and very warmly opposed by those who favoured different theories, notably the Neptunian theory of Werner, which attributed all the superficial parts of the globe to a state of aqueous solution, from which the materials were separated by chemical deposition.

Bakewell considered that stratified rocks were formed by the motion of water, and he distinguished the relative ages of rocks by their being *conformable* or *unconformable*, and gave sections of strata and of coal basins, also an outline geological map of England. He makes the remark that the early geologists were too fond of forming universal theories from a limited number of facts. He also alluded to the various names given to the same substance, from which the uninitiated might suppose

he was in company with masons fresh from the tower of Babel, each one calling the same stone by a different name. All geologists, however, it appears, were then agreed that every part of the dry land had once been covered with ocean.

Fifty years ago, when I was first studying geology, the formations were divided nearly in the same way as in 1813. The uppermost was the Recent Formation of soil, Alluvial, Diluvial, clay, sand, gravel and boulders. Next was the Tertiary comprising the strata above the chalk. Then the Secondary including the chalk with all down to the old red sandstone. Following this was the Transition. Lowest of all the Primary with Granite and such like as the base.

Lyell, early in his works, introduced into the Tertiary the terms Newer Pliocene, Older Pliocene, Miocene, Eocene, and kept to similar divisions of Tertiary and Secondary.

After this time important changes in the nomenclature began, being, as I understand, introduced mainly by Sir Roderick Murchison, who succeeded Sir Henry De-la Beche as the head of the Geological Survey of the United Kingdom.

The formations now according to a Table before me are divided into :—

The Cainozoic or Tertiary terminating as before at the top of the chalk.

The Mesozoic or Secondary terminating with the Trias or new red sandstone.

The Permian, with the Magnesian limestone.

The Palæozoic, beginning with the coal measures and terminating with the Silurian.

Metamorphic, or Cambrian.

Hypozoic, Chlorite and Mica, Slate Quartz, Hornblende, Mica Schist, Igneous Rocks, Unstratified Rocks, or Crystalline.

New names are, however, being frequently introduced, regardless of such satire as Bakewell's, which make the sub-

ject very perplexing to ordinary persons such as miners who have many other branches of science to study besides geology.

The terms Silurian and Cambrian have perhaps displaced some old names, such as Transition, which answered the purpose very well; but apparently many of the other changes in the names of some of the formations and the introduction of terms such as Permian, have been necessarily forced in by the discoveries made since the arrangement of previous tables.

The superposition of the principal formations appears to be now well authenticated, but possibly there is still something to learn respecting the connection of the Wealden, the Lias, the Trias, and the Permian.

The similarity in some of the beds in the Trias and the Permian makes it sometimes difficult to distinguish one from the other where the Permian fossils are absent. The whole of these with the overlying Saliferous marls are placed under the Lias, which is countenanced by general indications in Durham, Yorkshire, Cheshire, and Worcestershire. But I may say that it would be satisfactory if geologists made known any instance where rock-salt (not brine only) has been actually penetrated underneath the Lias, and thus remove the doubt which exists with some persons whether the Saliferous marls do not abut against the Lias, and other strata, and hold a higher position in the series than that assigned.

THE GLACIAL THEORY, is almost entirely new. The origin of the theory appears to be assigned to Agassiz, and the development of it to Sir Andrew Ramsay, who succeeded Sir Roderick Murchison at the head of the Geological Survey.

Ramsay in his work, "Physical Geology and Geography of Great Britain," says: "Geologists, led many years ago by

ɛ, have by degrees almost universally come to the sion that a very large part of the northern hemisphere uring the glacial period, covered, or nearly covered, a coating of thick ice." And, "It was only by s that geologists became reconciled to the idea that 'till' or boulder-clay is nothing but moraine rubbish vast scale formed by those old glaciers;" "this ıesis being now accepted by most of the best geologists ope and America." He says: "One thing is certain, efore the glacial epoch, the greater contours of the y were much the same as they are now, and that the ments of the Chalk and Oolite existed before the period."

r then were the greater contours formed; and what ə of the miles in thickness of ground which have eared.

drift, whether it be gravel, sand, or boulder clay, has ally stratified form, quite independent of the stratified ɔn which it rests. But there is not enough of it to t for what has been denuded from the contours.

ı a difficult problem. I gave my opinion on it before ciety nearly a quarter of a century ago, and although e popular notion, yet I still hold it to be the best n. Why do the basic or lowest geological formations rily occupy the highest elevations above sea level? hould rivers commonly flow from the basic to newer ions?

se things have undoubtedly been governed by some ıd apparently we must look for some other origin than denudation by water for the formation of the main rs, and beyond ice to account for the formation ains and drift.

ther progress in geology may, therefore, apparently ı to be made in this direction.

Mining.

The date when mining began is lost in obscurity.

In cutting through very ancient workings, at shallow depths, in the iron ore of the Forest of Dean, spades cut out of solid wood have been found, without any appearance remaining of their having ever been tipped with iron.

Sacred writ, notably the patriarch Job, in the revised version, mentions several metals and the melting and refining, and that "there is a mine for silver," and that "iron is taken out of the earth," and "underneath it is turned up as it were fire."

In the year 1556, Agricola, in the book entitled "Georgii de re Metallica," said to have been written by George Landmann, a medical gentleman, who assumed the name of Agricola, or peasant, gives drawings and text showing that at that time, shafts and workings were timbered, ladders used, also four-wheeled hutches, barrows, sledges, and carts.

That winding and machinery comprised ropes, hoppets, windlasses, rotary machines turned by men treading inside vertical wheels and on the top of horizontal wheels, also pulling by hand, capstans with four arms, gins worked by horses, wheels turned by horses, waterwheels, windmills, chains, and brakes.

That water was raised by ordinary suction pumps of various construction; pumps with wooden pump trees, and with an intersecting box and crank for forcing; by endless chain pumps with hopper buckets, and with elongated spheres at short distances apart working like buckets in pump trees, the chains being both single linked and double linked.

That ventilation was produced by means of air-pipes and bratticed shafts. Naturally, by boards being set up to direct the wind down one side, and by rotating barrels moved by a vane with a hole in the barrel to catch the

. By ventilators, namely :—Fans with plane and with
ed vanes, also bellows; and that cloths were used for
ng bad air by batting or flapping.
at among work tools were the hammer, the pick, crow-
and wedge.
at rock was softened by burning wood.
at the means of lighting was by hand lamps.
at means were used for surveying and levelling and
secting workings.
at in dressing the ores women as well as men were
oyed.

1814, a Society in Sunderland for the prevention of
ents in coal mines printed a paper by Mr. John Buddle,
minent coal viewer of Wallsend, dated 1813, which set
that the only methods then known for preventing
sions were by the thorough ventilation of the several
ges and workings of the mine.

gave drawings showing that in ventilation the air was
ed through every part of the workings, as introduced
r. Spedding, of Whitehaven; and that air was divided
currents or splits, called compound ventilation; doors
swing doors hung within a recess in the roof for use
e event of an explosion blowing out the others; air
ings made of brick or plank; bratticing, with screens
ending air into holes in the roof; stoppings, the main
being supported by stowing or rough walling.

r lighting, candles were used between the shaft and
urthest stenting or cut-through; and steel mills acting
int beyond the cut-throughs.

ie presence of inflammable gas, from the slightest
ure, through all its gradations to the firing point,
readily discovered by an experienced collier, and he
ed very correctly of the degree of inflammability and
er which threaten the safety of the mine, by attentively

observing the appearance of the spire or cap upon the top of the candle.

The common pit candles varied in size, but those generally used were forty-five to the pound; the wick was of cotton, and the candle made of ox or sheep tallow; but clean ox tallow was best.

The mode of trying the candle, as it was called, to ascertain the mixture of inflammable gas, was as follows:— In the first place, the candle, called by the colliers the low, was trimmed, that is, the liquid fat was wiped off, the wick snuffed short, and carefully cleaned of red embers, so that the flame might burn as purely as possible. The candle being thus prepared, it was holden between the fingers and thumb of the one hand, and the palm of the other was placed between the eye of the observer and the flame, so that nothing but the spire of the flame could be seen, as it gradually towered over the upper margin of the hand. The observation was generally commenced near the floor of the mine, and the light and hand were gently raised upwards, till the true state of the circulating current could be ascertained. The first indication of the presence of inflammable air was a slight tinge of blue, or a bluish grey colour shooting up from the top of the spire of the candle, and terminating in a fine extended point. This spire increased in size, and received a deeper tinge of blue as it rose through an increased proportion of inflammable gas, till it reached the firing point; but the experienced collier knew accurately enough all the gradations of show (as it was called) upon the candle, and was very rarely fired upon, excepting in cases of sudden discharges of inflammable gas.

The show upon the top of the candle varied very much, according to the length of the run, or distance, which the current of air had passed through, before it is mixed with the inflammable gas. The shorter the run of the current of

air, before it is mixed with the inflammable gas, the less would be the show upon the candle when at the firing point and vice versa.

The same size of spire would indicate danger in a current which had passed only one mile, might be perfectly harmless in a current that had run five or six miles. Consequently, the length of the run of air had to be taken into consideration as well as the appearance of the top of the candle. The air course too, for a short distance beyond a small discharge of firedamp, might be highly inflammable, but by passing a few yards further, it became so diluted as to be perfectly secure. The distance, therefore, within which a blower can be safely approached with candles was regulated entirely by the magnitude of the discharge and power of the current of air. Long experience and attentive observation were consequently necessary to obtain a thorough practical knowledge of this art.

The workings of a colliery were very often inaccessible with candles near the downcast pit, called the first of the air, while they might be safely entered with any description of lights near the upcast pit, called the last of the air. This arose from the inflammable gas, as it was carried from the place of its discharge, being gradually diluted by the atmospheric current. Hence the advantage of sufficient extent of pit room to obtain length of run to dilute the inflammable air. It was from want of pit room that the explosions in newly-opened collieries were generally the most violent. The run of air, or the distance which the current of air passed through between the downcast and the upcast pits, varied much according to circumstances. It was known to exceed thirty miles.

After the current of atmospheric air was so highly mixed with inflammable air, as not to be accessible with lighted candles, steel mills might be employed with safety.

Although the inflammable air had frequently fired at the sparks of the steel mills, it only happened, from all the facts which Mr. Buddle had been able to collect, when the mills were played near the place where the hydrogen gas was discharged, and that, by due attention, might easily be avoided. He never, indeed, witnessed an explosion from the sparks of flint; but from his own observations on their appearance in dangerous states of air, as well as from the observations of several intelligent men, he believed that in most cases the change of the appearance of the sparks, if attentively observed, gave sufficient notice of the threatening danger. When elicited in atmospheric air, they were of a bright appearance, rather inclining to a reddish hue, and as they flew from the wheel, seemed sharp and pointed. In a current of air, mixed with inflammable gas above the firing point, like as with candles, they increased considerably in size, and became more luminous. On approaching the firing point with steel mills, they grew still more luminous, and assumed a kind of liquid appearance, nearly resembling the sparks under the hammer from iron at the welding heat. They also adhered, more than usual, to the periphery of the wheel, encompassing it, as it were, with a stream of fire, and the light emanating from them was of a bluish tint. When the inflammable gas predominated in the circulating current, the sparks from the steel mill were of a blood red colour, and as the mixture increased, the mill totally ceased to elicit sparks. They had the same bloody colour in carbonic acid.

The improved system of ventilation was introduced into the collieries on the Tyne and Wear, about the year 1760. It proved inadequate in the following cases:—

1st. When sudden discharges of inflammable gas mix the whole mass of circulating air to the firing point.

2nd. When the wind was at south-east, the weather wet

or hazy, and the barometer sunk below 29 inches. In that case the atmospheric current, which under the most favourable state of the air was merely sufficient to sweep off the noxious effluvia of some mines, got so contaminated by the increased discharge of inflammable gas, and the slowness of its own progress, as to become exceedingly unsafe, and generally inaccessible with candles.

3rd. When inflammable air filled a part of the mine between the workmen and the upcast shaft, and a fall of stone from the roof, or other causes, occurred to force it back upon the workmen's candles.

4th. When the gas was lighted by lightning as it ascended the upcast shaft.

To obviate these defects as much as possible, Mr. Buddle introduced the double or compound ventilation, apparently splitting or dividing the air into different currents, and introduced the steam ventilator, the air pump, and hot cylinder. He gave drawings of these in his Paper, and of the furnace and the waterfall, and said that exhausting air was found preferable to forcing.

The standard air-course was from 30 to 40 feet in area, and the velocity of the current 3 feet per second or 180 feet per minute.

On the strength of his own experience he was of opinion that any further application of mechanical agency would be ineffectual towards preventing explosions in coal mines, but he had hopes of some method being discovered of producing such a chemical change upon carburetted hydrogen gas, as to render it innoxious as fast as it is discharged, or as it approaches the neighbourhood of lights.

In this Paper, Mr. Buddle recommended the formation of a general Permanent Fund for the relief of the widows and orphans of such colliers and others as may lose their lives in the collieries on the Tyne and Wear, and for the support of such as are maimed and disabled.

In 1835, a Select Committee of the House of Commons inquired into the cause of catastrophies which had occurred in the mines of Great Britain, with a view of suggesting means of prevention. This Committee had before them almost every topic connected with collieries: The nature and cause of accidents: The amount of damage sustained by loss of life and to property by explosions: Coroner's inquests, and the expediency of some fit and proper person attending to assist the Coroner and jury in their investigation: Fire-damp: Carbonic acid and other noxious black-damp gases: Roberts's Safety Hood to enable persons to enter places charged with noxious gas: Inundations of water: A long list of casualties, some of which appeared inseparable from mining pursuits: Ventilation: Safety lamps: Maps or plans: Bratticed ventilating shafts, which in common with general opinion they reprobated: Foul and free air-courses being too near to each other; the long lengths of air coursing; "Boards" and "Ends" often imperfectly united, and the temporary nature of stoppings, some being made of mere heaps of small coal, giving opportunities for leakage, interruption and contamination: How far legislative enactments might fairly come in aid of the miner: The dependence to be placed on agents, viewers, or managers and subordinate overseers, under whatever name they may be called: Daily reports from subalterns: Moral culture: To which, as the Committee reported, there still remained to be exercised that quick perception of cause and effect, that accurate adaptation of means to the end, that nice observation of various natural phenomena connected with the state of the atmosphere at the surface and underground, upon which it is obvious safety must ultimately depend; together with the necessity that everything possible should be done to bring the workmen acquainted with their individual responsibilities and those theories and principles

n the observance of which their personal existence and
t of their comrades are at stake.

n 1839, Sir Charles Lemon, Bart., M.P., at his own
ense, commenced at the Royal Institution, Truro, an
erimental Mining School, and continued it for a term in
spring of that year and in 1840; Professors Moseley
Hall, of King's College, London, taking respectively
mechanical and mathematical classes, Mr. Prideaux, of
mouth, the metallurgical class, and myself (being then
ny pupilage) taking the preliminary classes, during both
ns.

About the same time was established in Craig's Court,
aring Cross, London, a Government Institution, consisting
a geological museum, a chemical laboratory, and an assay
nace. Here, for a term in 1843, being sent by Sir J.
n Guest, Bart., M.P., for purposes of the Dowlais works,
ook lessons in chemistry and assaying under Mr. Richard
llips, F.R.S. This establishment has since become ex-
ded with numerous professors of similar high standing
the Mining School and Museum at Jermyn Street, and
onnection with those at South Kensington.

n 1840, having finished my pupilage, or served my time,
h Mr. Thomas Sopwirth, F.R.S., Civil and Mining
gineer, of Newcastle-on-Tyne, I, on the recommendation
Mr. Sopwith and Mr. Buddle, whom I had the privilege to
ow, entered on duty in the extensive mines and ironworks
Dowlais, in South Wales, and I found the ventilation
re in a similar state to that described by Mr. Buddle.

The currents of air were long, and in the return air of the
y mines some of the caps above the flame of the candles
re occasionally two or three inches in length. These
ps were of a blue colour with a greyish tinge, but some-
at different to caps in the intake air, where a very much

smaller but bluer cap indicated the firing point the same as it does now.

The shafts being large and the airways small, boisterous winds on rare occasions reversed the ventilation, and necessitated the furnace being extinguished.

The Davy lamp was used by the firemen in making the examination before the miners commenced work, as at present, and the lamp was carried in a tin case.

The safety lamp was used only by the firemen, except in exceptional circumstances, the using of them being considered likely to bring a bad name on a colliery.

I had generally to test with the candle, and with practice I could judge the state of the ventilation to within about one yard of the firing point, which I tested occasionally with a safety lamp. The gas never fired at my candle, but I have seen it fire at one carried by another person, and the flame flash along the side of a magazine of fire-damp, when fortunately there was not enough air amongst the gas to make it explosive. I have also been in the mine and been blown down by an explosion. The first sensation of an explosion as experienced by me is on the ears, by the suck of air, and then comes the blast, the feeling being one of helplessness, and if the flame does not come so far is followed by suspense lest the possibility of retreat may be cut off by after-damp.

Powder was occasionally used for blasting under these circumstances, and the return air had to go through the ventilating furnaces, the furnaces and upcast shafts, called flues in South Wales, and cubes elsewhere, to distinguish them from furnaces about the iron works.

Some women were then employed below ground, and some little girls tented air doors.

In 1842 was passed the Act 5 & 6 Vict., c. 99, to prohibit the employment of women and girls in mines and collieries,

and to regulate the employment of boys, and to make other provisions relating to persons working therein; boys under 10 years of age ceasing to be employed under ground other than such as had attained the age of nine years; and women ceasing to be employed below ground other than such as were at or before the passing of the Act employed. An inspector was appointed under the Act to see to the provisions.

In 1849, the Select Committee of the House of Lords had before them many points relating to coal mines, new and interesting, but nothing materially at variance with the results of the 1835 Committee of the House of Commons. The points consisted of papers from time to time presented to Parliament comprising reports of the Commission for inquiring into the Employment of Children in Mines and Manufactories in 1842; the report of the Midland Mining Commission in 1843; the report of the South Shields Committee in 1843; the practicability of a judicious system of inspection; many ingenious suggestions and inventions, including the plan of Mr. Goldsworthy Gurney submitted to the Committee of 1835 for applying high pressure steam-jet to the ventilation of mines; the centrifugal fan for effecting the same object by Mr. Brunton; the patent air pump invented by Mr. Struvé; means of ventilation by rarefaction and natural; Mr. Fourdrinier's safety apparatus for catching the load in the event of breakage of shaft ropes; the danger of mouthings in shafts and falls of roof; plans; record plans; safety hood and lamp for entering mines after explosions; Biram's registering cylinder for recording the revolutions of an anemometer.

In 1850 was passed for five years the Act 13 and 14 Vict. c. 100, being the first Act for Inspection of Coal Mines in Great Britain, and under which four inspectors of mines were appointed in November, 1850, of which I was one.

Mr. Matthias Dunn, one of the first four of Her Majesty's Inspectors of Mines, found on entering on his duties that in Northumberland and Durham, "the managers seemed to vie one with another in adopting the best means of safety," and ventilation and mechanism further advanced than elsewhere in his district. In Cumberland, "colliery improvements were considerably behind, with certain exceptions;" and with a single exception the collieries "continued to work with baskets." In Scotland, "there was a greater succession of accidents in proportion to the number of persons employed than in England," but "slides and cages" were almost universally in the shafts, and the system of working by long-wall was prevalent, similar to what it was in the Midland Counties, but had never until very recently been attempted in the North of England.

Mr. Charles Morton, another of the first four of Her Majesty's Inspector of Mines, on entering on his district found collieries in which mining plans, sections, and records were not universally kept. Also collieries in which carbonic acid gas or blackdamp sometimes extinguished candles. Safety lamps were used for testing with in the Midland portion of the district, but in Yorkshire they were in frequent requisition, the Davy being the one usually adopted, but a few Clanny's.

Mr. Kenyon Blackwell who was also appointed, scarcely acted, if indeed at all, and for about six months his district of South Wales, Monmouthshire, and Gloucestershire, was put under my care.

On entering on my duties in 1850 as Her Majesty's Inspector of Mines in Lancashire, Cheshire, North Wales, Staffordshire, Shropshire and Worcestershire, I found that in South Staffordshire the Davy lamp with two gauzes was used. In Lancashire, the Davy with one gauze and the cap above was used. I found at St. Helens, in some

mines with sluggish ventilation, it was customary to burn firedamp in places in advance of the air. This, as I have watched it, was done by lighting the extreme tail end of the gas, which sent flame hissing along to the face about as quickly as a person could walk.

As the flame passed, it lighted the feeders of gas and left them burning with blue flames, which had to be flapped out. This was in fiery mines, but, of course, where there was not sufficient air to make the mixture explosive. It was called burning out the firedamp. If air became sucked in sufficient to cause an explosion it was said to have burst.

This was practised where powder was used for blasting, the burning and flapping out had to be done before firing a shot, and the flapping out to be repeated after the shot had relighted the feeders.

In North Wales, which then formed part of my district, the ventilation was worse than in Lancashire. In one colliery near Holywell, where miners were at work, I found the return air issuing from the upcast shaft at the explosive point, with a footpath close to, and the wall round the shaft only about four feet high, so that a match struck on the top of the wall would have caused a general explosion.

Some persons were burned in those days in testing with the candle, being deceived by the much smaller blue cap shown with a dry atmosphere or on a clear frosty morning.

These momentous times have nearly passed away. But the transition from inactive ventilation, with scarcely sufficient air in the gas to cause a general explosion, to the active ventilation which makes explosions much more violent, has not been effected without many thrilling scenes.

One of the first things which I did on becoming Inspector of Mines was to discountenance testing for gas with the open light, and to have the ventilation improved.

In 1852, a Select Committee of the House of Commons

went over the same topics as the preceding Committees, and over some new matter.

They concluded that:—Without a current of air at the rate of at least four feet per second in every part of a mine at all fiery, the miner cannot be considered safe from explosion: A partial introduction of an insufficient quantity of atmospheric air into a fiery mine may cause the very mischief against which it is intended to guard: With furnace ventilation explosions are more frequent in warm weather: The Davy Lamp, referring to experiments by Dr. Bachhoffner, is insecure under certain circumstances: Scientific instruments should be used, naming the self-registering anemometer; a water gauge, to be placed at the bottom of the upcast shaft to show the drag of the air in the mine; a thermometer; a barometer—a differential one, as it is much more sensitive than a common one; refuge stalls to flee to after an explosion: a special coroner to hold mining inquests: a Board, with greatly increased powers: more inspectors, the number then being six; and sub-inspectors, the inspectors to have power where great danger evidently exists to cause the working of a mine to cease temporarily until the matter could be referred to the Board: the establishment of mining schools: the better education of miners: the circulation of regulations: the families of those who perish to be supported for a limited number of years by the proprietor of the mine: they mentioned a suggestion that if water would permit, boreholes should be put down, with a steam-jet at the top to draw gases from goaves, and, for a similar purpose, gas drifts: they introduced, also, an alleged discovery by Mr. Goldsworthy Gurney, of what were called the Furnace Paradox, the Natural Brattice, and the Furnace Limit; and they concluded by representing the steam-jet as being the most powerful and least expensive method for the ventilation of mines.

In 1853 and 1854 a Select Committee of the House of Commons went minutely into the working and ventilation of mines, and into what improvements had taken place since the former Committees, resulting in the recommendation of certain rules for diminishing the number of accidents which afterwards became incorporated in the second Act for the Inspection of Mines. They referred to the House of Lords having called attention to the steam-jet, and to the Committee of the House of Commons, 1852, having reported in favour of it, but said that investigations on a much larger scale had since shown that the furnace is the most effective as well as the most economical ventilating power; and that the objections raised against the furnace, under the titles furnace limit, furnace paradox, and, natural brattice were theoretical views, and did not establish any positive law affecting prejudicially the action of the furnace.

At the time of the Committee in 1852, and that of 1853-54, feeling amongst some of the mining community ran very high respecting the relative merits of the furnace and the steam jet.

For the information of some of the present generation who did not take part in and may not have read what was then passing, I may describe what was meant by Furnace Paradox, Natural Brattice, and Furnace Limit.

By "Furnace Paradox" was meant that the visible indication of the pressure shown by the water-gauge between the up-cast and the down-cast shafts was no measure of the ventilation, because if the water-gauge rises higher there ought to be more ventilation, but if there is anything to impede the supply of air going up the up-cast will be less and the pressure-gauge higher, indicating a larger force when the air is in fact cut off. The reply to which was that it was a natural law and no paradox, the gauge indicating only a higher amount of exhaustion.

The "Natural Brattice" was where in a large up-cast shaft cold air had been observed to go down one part and the heated air come up the other part. To this it was replied that such a thing could only take place in stagnant shafts, in cases which ought never to exist in a well ventilated colliery.

The "Furnace Limit" was when the furnace could not produce any more ventilation. It was not, so far as I remember, set forth at the time what the temperature in the shaft was when this limit was attained, but in the work "Traité de la Chaleur," by M. Peclet, published in 1860. It appears that when the temperature in any furnace shaft or chimney becomes so high as to expand the heated air, &c., to double the original volume the friction then becomes so increased as to prevent the passing of any increase in the volume.

I do not know whether this law as laid down by Peclet has been verified by experiments in our own country, but among the experiments in testing the various ventilating powers made by Mr. John Job Atkinson and myself, was one with a balling furnace at the Dowlais Iron Works, in which we measured the air by anemometers and the temperatures by the pyrometer and the melting heat of lead, copper, and silver; the result of which apparently confirmed the conclusion arrived at by Peclet, but unfortunately we made the experiment during the heating of the chimney when the charges are too rapid for exact observation, and not during the cooling when it is gradual, and we never had an opportunity to repeat it. The very high temperature requisite to expand air to double the original volume is, it is almost needless to say, such as could not be attained in any ordinary mining shaft.

In 1855 was passed, for five years, the Act 18 and 19 Vict.,

. 108, repealing the former Act, and introducing seven general rules for safety, which were the result of a visit to he continental mines by the late Mr. Mackworth and myself, as reported by us to the Committee and endorsed by Mr. Wynne and Mr. Williams, being by four of the then ix inspectors of mines; and in addition the establishment of pecial rules was made obligatory.

Shortly after the passing of this Act the number of nspectors was increased to twelve.

In 1860 was passed, for an unlimited time, the Act 23 and 24 Vict., c. 151, for the regulation and inspection of mines, which amended the former Act, together with the Act 5 and 6 Vict., c. 99, and increased the general rules for safety to fifteen.

In 1862 was passed a supplementary Act, 25 and 26 Vict., c. 79, requiring two shafts or outlets in all except certain mines, the necessity appearing from the loss of 209 lives by the breakage of the beam of a pumping engine at Hartley colliery, in Northumberland, which broke down the brattice on a single shaft and cut off all egress.

In 1864 a report was made by the Royal Commission to inquire into the condition of all mines in Great Britain to which the provisions of the Act 23 and 24 Vict., c. 151, did not apply, and to suggest the most practicable means of improving the health and safety of persons employed in such mines.

The Commission found the health of the copper, tin, and lead miners in Cornwall as a class greatly inferior to that of persons engaged in open air employments, and in excess of northern coal miners, the average annual number of deaths per 1,000 from all causes during the five years 1849–53 inclusive being :—

	Metal Miners.	Coal Miners.
Between 15 and 25 years ..	8·90 ..	8·50
„ 25 „ 35 „ ..	8·96 ..	8·49
„ 35 „ 45 „ ..	14·30 ..	10·13
„ 45 „ 55 „ ..	33·51 ..	16·81
„ 55 „ 65 „ ..	63·17 ..	24·43
„ 65 „ 75 „ ..	111·23 ..	65·16

The average number of deaths per 1,000 males, exclusive of miners, from all causes during the three years 1860–62 inclusive being respectively 7·50, 8·32, 10·08, 12·50, 19·96, 53·31.

The access and egress by ladders caused great waste of time and strength of the miner, the greatest depth to climb being then 1,680 feet, there being mines in which three hours were expended by the miner in going to and returning from his work. At some mines there was a Fahrkunst or man-engine, and at a few the men rode in a skip.

The ventilation was often very imperfect. There was carbonic acid given off in Cornwall, but not any evidence of inflammable gas.

The work at the dressing floors above ground was partly carried on by a few men disabled from working below, but principally by women and children, who were remarkably healthy.

In 1866 and 1867 a Select Committee of the House of Commons recommended further regulations as to the employment of boys; additions to general rules for safety; increased number of inspectors; weighing clauses; exclusion from juries and the bench of persons known to be interested; but they did not after careful consideration recommend the prohibition of the employment of women on pit banks.

In 1871 the Royal Coal Commission appointed to inquire into the several matters relative to coal in the United Kingdom, of which I was a member, reported that:—

ossible depths of working depend upon human
e of high temperatures, and upon the possibility of
the temperature of the air in contact with the
ata. The increase of temperature is very irregular,
erage may be taken to be 50° Fahrenheit at a depth
50 feet, and the rate of increase of the temperature
ata in the coal districts of England about 1° Fahr.
60 feet of depth.

antity of available coal in the known coal-fields of
d Kingdom, excluding all beds of coal of less than
n thickness, amounted to 90,207 millions of statute
depths not exceeding 4,000 feet, and after the
deductions.

ition the probable amount of coal under Permian
overlying formations at depths of less than 4,000
73 millions of statute tons, making an aggregate of
nillions of statute tons, which might be reasonably
to be available for use.

ition to which there was and is in the known coal-
ut 7,320 millions of statute tons at depths exceeding
t.

here insert that in 1886 the annual production of
he United Kingdom was 157 million tons, from
ne idea may be formed of the probable duration of
ields.

Vaste in Working" the Commission Reported that
ierally a manifest improvement was being made by
sion of the system of "long wall," yet that much coal
by bad working and by carelessness, the loss being
s under control and sometimes unavoidable. The
waste was from pillars being crushed, in addition
was that from small coal being left below ground,
ied in large heaps on the surface:

equisite holing or undermining being wastefully
good coal:

Coal being left behind where it becomes crushed and unworkable hereafter, because it is of a kind that is not wanted at the time, or if it were worked the cost per ton of the coal got would be increased:

Properties which alone are too small to form a separate colliery, or a part of a property severed by a large fault, being passed by during the working of the adjoining coal and left unworked:

Coal being left unworked through contention as to which of two or more owners should pump the joint water, and portions of seams to the dip rendered unworkable by water allowed to flow from other properties when it might be run off by free drainage or pumped at a shallow depth:

Inundation by river, sea, or estuary breaking into the workings consequent on the removal of pillars, or incautiously working too near the surface; also by large areas of coal which must subsequently be left sacrificed against such inundated workings:

Barriers being left around small properties, or crooked boundaries, when a barrier properly laid out would be more economical and afford the same or more effectual protection:

Large tracts of coal of uncertain area being left as barriers owing to there being no plans or records available to show the extent of the old workings or explorations:

Also by areas not sufficiently proved to justify the expenditure for sinking pits being left when sufficient information might have been obtained had the records of previous explorations and copies of the sections of borings been preserved in an available form.

Strata yielding a continuous supply of water being pierced by shafts and boreholes, and left unprotected by water-tight casing or not carefully filled up and puddled when the working ceased or was abandoned:

Main faults serving as natural barriers to keep back water

being cut through, and the coal on the other side thereby flooded.

In populous and manufacturing districts large areas of coal being left for the support of the surface and buildings.

The Commission hesitated to suggest how far the legislature may deem it expedient in the public interest to deal with any of these sources of waste by special enactment.

At the time of this Commission the greatest depth attained in any coal shaft in England was 2,376 feet.

The greatest depth reached now by vertical shaft is 2,850 feet, which is at the Ashton Moss Colliery, Audenshaw, near Manchester. Depths of 3,000 feet have now been reached in Pendleton Colliery, Manchester, but nearly one half of that is by inclines underground.

Since the report was made many collieries have been worked out and the shafts filled up, leaving scarcely a vestige except plans to show where some of the finest and easiest accessible coal has been obtained.

In 1872, was passed the Coal Mines Regulation Act, 1872, 35 and 36 Vict., c. 76, which consolidated and amended the former Acts, repealing the whole of the 5 and 6 Vict., c. 99, and the whole of the 25 and 26 Vict., c. 79. In this Act managers were first required to be certificated, and the general rules relating to safety increased to thirty-one.

In 1872 was also passed the Metalliferous Mines Regulation Act, 1872, 35 and 36 Vict., c. 77, comprising all mines not included in the Coal Mines Act.

After the passing of these two Acts of 1872, two inspectors of metalliferous mines only were appointed; and each of the twelve existing inspectors of coal mines were appointed inspectors of metalliferous mines also, and to each of these twelve was appointed one inspector to assist, making the total number of inspectors twenty-six.

Ireland became comprised in the inspection under these Acts of 1872, and was assigned to me.

Supplementary Amending Acts to the Metalliferous Mines Regulation Act, 1872, were passed, namely, in 1875, the 38 and 39 Vict., c. 39, as to the annual returns, and in 1882, the Slate Mines (gunpowder) Act, 1882, 45 Vict, c. 3.

These were followed by Supplementary Amending Acts to the Coal Mines Act, 1872, namely, in 1881, the Stratified Ironstone Mines (gunpowder) Act, 1881, 44 and 45 Vict., c. 26; and in 1886, the Coal Mines Act, 1886, 49 and 50 Vict., c. 40.

In 1873 a Select Committee of the House of Commons reported on coal, chiefly in connection with the consumption and temporary scarceness of coal and consequent high prices and wages, the selling price in London having gone up from an average of 18s. or 19s. to 32s. 6d., and miners wages up to a gold coin for a days work.

The Committee expressed their belief that the true policy of the country and the best inducement to the proper conduct of business, as well as the greatest stimulus to a return to a more just balance between supply and demand, was to leave the trade free, and to maintain an inflexible resolution of non-interference on the part of the State.

In 1885, seven additional inspectors were appointed, being selected from among persons holding managers' certificates, one being assigned to assist in each of the large districts, making the total number of inspectors thirty-three.

In 1886, a Royal Commission reported on accidents in mines and the possible means of preventing their occurrence or limiting their disastrous consequences, they having made a preliminary report in 1881 dealing with the matter in question. Experiments with safety lamps and explosives were made on an elaborate scale, and information obtained

on the various matters referred to them, some of the results being incorporated into the Coal Mines Regulation Act, 1887.

In 1887 has been passed the Coal Mines Regulation Act, 1887, 50 and 51 Vict., c. 58, which comes into operation on the 1st January, 1888, repealing and re-enacting with amendments the Coal Mines Acts of 1872, 1881, and 1886. In this Act, certificated under managers are introduced in addition to the managers, and the general rules relating to safety are increased to thirty-nine. Boys are not to be employed under 12 years of age, and persons for working the machinery for lowering and raising persons are to be males as before, but to be 22 years of age or more, those boys between 10 and 12 and the enginemen of 18 years already employed being exempted.

In addition to the Committees of the House of Lords and Commons and Royal Commissions and the mining institutes mentioned, other mining institutes have collected and diffused most important and valuable information on various branches of mining. The miners' unions and federations, and some persons acting singly, have also assisted greatly in the progress which has been made.

Two special subjects require commenting upon, namely, mine ventilators and safety lamps, before entering upon the concluding part of this address.

VENTILATORS:—Up to fifty years ago, in England the principal ventilating power used was the furnace. Mr. Buddle's paper 1814 shows this, and in the 1835 Committee Report drawings of it are shown with a dumb or pipe drift for air from gaseous mines to pass clear of the fire.

The mechanical ventilators such as fans, pumps, and water-blast then used were only on a small scale.

The same may be said as to steam which at first seems to

have been used as heating power only, and not as blast until afterwards except the discharged steam from engines.

The first large mechanical ventilators which came under my notice were the Biram fan, the Nasmyth fan, and the Struvé air pump.

The Struvé had two large cylinders made of thin wrought iron, which worked up and down in a disc of water, and had large lightly framed inlet and outlet valves placed vertically. Several of these were worked about 30 years ago.

The Biram fan was self-contained and worked horizontally, the Waddle and the Rammell, introduced a few years afterwards, being of like principle, but working vertically.

These were followed by one or two large horizontal pumps, one of the earliest of which (Nixon's), is, I believe, still at work at Navigation Colliery, in South Wales.

At the continental mines to which, in conjunction with the late Mr. Mackworth, I was sent on a mission by Lord Palmerston, to Belgium, France, and Germany, early in 1853, we found mechanical ventilation very common in Belgium. They were all exhausting air, and they were seven in number, as described by us and given in the report of the Committee of the House of Commons, 1853, namely:—

The Fabry, which had two shafts revolving in contrary directions, with three vanes fitted to each shaft, which isolated and discharged the return air.

The Letoret, which was a fan with the vanes carried out at right angles about half way, and were then bent back at an angle of 110°, resembling the Nasmyth fan in England, except in the angle of the vanes.

The Pasquet, with three revolving vanes on the principle of the revolving chimney top; but a large one was being constructed with six vanes, resembling the Biram fan in England.

M. Pasquet had also a ventilator similar to the Fabry.

The Lessoine, similar to the Pasquet, but with more vanes, resembling the Biram.

The Motte, on the principle of the archimedean screw.

The Piston and Wooden cylinder, which had been at work 18 years near Liège without any failure. This was similar to the one shown by Mr. Buddle, but differed from Mr. Struvé's by having the valves horizontal instead of vertical, and by not working in water to prevent leakage.

The Lamielle, then a new ventilator with a revolving hexagonal cylinder, the sides of which opened and shut by an eccentric, by which the air was isolated and thrown out.

These ventilators were then working with a water gauge under 2½ inches, and the maximum amount of air obtained was 38,000 cubic feet of air per minute, which was by a Letoret.

At the time of the Committees of 1852 and 1853–54 the steam jet was tried as ventilating power on a large scale. The principal places where I witnessed it were at Seaton Delavel, in Northumberland, by Mr. T. E. Forster; Hetton, in Durham, by Mr. Nicholas Wood; Ince Hall, in Lancashire, by Mr. James Darlington; and at Worsley, by Mr. Fereday Smith. The best of these appliances I considered to be at Ince Hall, where the cone of steam from the jets issued into zinc cylinders, each six feet long by one foot in diameter, the jets being placed fifteen inches outside of the cylinders, drawings and details of which are given in the 1853 Committee Report.

In 1855 a steam heater, consisting of a grating of pipes heated with steam around the upcast shaft, was applied at the Vron Colliery, in North Wales.

Commencing in the year 1861, my colleague, the late Mr. John Job Atkinson, and myself, made experiments with some ventilating furnaces, and all the known mine

ventilators then in use in England and in Belgium, France, and Germany.

On making a second visit to the mines on the continent in 1862, and a third in 1863, I found that an air pump called the Mahoux, worked horizontally like the Nixon, had been used rather extensively, but that it and some of the others were being discontinued, and the fan principle most approved of.

It would be needless to go over the details; suffice it to say that fans on the principle of the present Guibal, the Waddle, and the Schielé were found to utilise the most power.

These fans, with improvements, together with other fans, are now the approved ventilators in the United Kingdom, and are steadily superseding the furnace; although, for small amounts of air, pumps, water-blast, steam jet, and such like are still used with advantage.

THE FIRST SAFETY LAMP appears to have been invented by Dr. Clanny, in 1813, but it was cumbersome and had to be fed with air forced through water from a bellows, and was entirely different to the lamp now called the Clanny, which is on the principle of the Davy.

In 1816 Sir Humphrey Davy and Mr. George Stephenson made their inventions of safety lamps. The Davy depended on the principle that flame will not readily pass through wire gauze, and the Stephenson that it will not pass through tubes of a certain diameter. Since then, the same principle has been introduced in a variety of ways into many other lamps bearing various names.

In 1833 Dr. Priara made experiments with the Davy lamp in explosive coal gas which showed that it was not safe in quick currents.

The 1835 Committee of the House of Commons pointed out that the principle of the construction of the safety lamp

appeared to have been practically known to Clanny and Stephenson previously to the period when Davy brought his powerful mind to bear upon the subject and produced a lamp which will hand down his name to the latest ages. They had also before them the contingencies in mining under which the lamp ceases to afford adequate protection, of the possible existence and nature of which contingencies the Committee ascertained that the inventor was well aware, and they regretted that the cautions he gave to some of his immediate friends were not made more public: Also the difficulty in comparison with the common candle in bringing the Davy lamp into use: Also many improved lamps calculated to lessen the number of dangerous contingencies, all being extensions of the same principle. The lamps produced were by Upton and Roberts, Newman, Martin, Douglas, Wood and Dillon. The lamps of Dr. Clanny and Ayres were provided with mechanical contrivances intended to exclude danger which might overcome the safety principle and at once warn the miner by the extinction of his light. Experiments were made before the Committee at the London University, which, although not quite satisfactory, were such as produced explosion of the gases within each of the lamps, and externally also, in every one save Messrs. Upton and Roberts's, of the paramount merits of which the Committee were decidedly convinced. The introduction of of glass was not then new; the novelties were the shape of the glass, the collar which regulated the admission of air or gas to the cotton wick and the double tissue of gauze beneath the wick which prevented firing backward. The Committee had also the statement of Mr. Buddle before them that tin shields and a partial concealment of the lamp under their dress constituted the prudential precautions taken by the miners in dangerous situations to prevent the flame passing the gauze when the lamp is agitated.

In 1850, in South Staffordshire, as previously stated, I found the Davy with single gauze was distrusted, lamps with two gauzes being used for testing.

The 1852 Committee of the House of Commons reported, that where a proper degree of ventilation does not exist in a mine the Davy lamp or any modification of it must be considered rather as a lure to danger than as a perfect security, it is practically secure in a still atmosphere, and in the hands of a cautious man is an admirable instrument for exploring or as an indicator of danger, but in a current as admitted by its inventor it is not a security, and in the hands of an ordinary workman when danger is threatened is not improbably the very cause of the explosion which it is intended to prevent. They recommended a lamp of greater reflecting power, which would admit of a double gauze protection.

The Transactions of the North of England Institute of Mining Engineers set forth that in 1853 a series of experiments were made with various safety lamps by Mr. T. J. Taylor and Mr. Nicholas Wood in fire-damp, which showed various rates at which flame passed in an explosive mixture, the passing being quicker in coal gas than in fire-damp.

The Committee of the House of Commons in 1853-54 had detailed to them the results of experiments conducted by Messrs. Wood and Elliot, to test the powers of resisting of all the lamps which up to that time had been invented, and concluded to the effect that safety lamps added largely to the security from explosion, and can be used without much if any extra cost over the naked light, but that the ventilation should be so good that under ordinary circumstances it would be safe to work with naked lights, and that safety lamps, however valuable, should not be relied upon for the preventing of explosions.

In 1863 a committee of the North of England Institute

of Mining Engineers, in which Mr. Lindsay Wood took an active part, made an extensive series of experiments in the Eppleton Pit, Hetton Colliery, in which similar results were ascertained. These experiments were made first by revolving the lamps in a box containing a mixture of fire-damp, and afterwards by placing the lamps in a pipe through which the inflammable mixture was passed. A report is given in the Society's Transactions, in which the committee made known "the insecurity not previously fully appreciated and realised of the safety lamps so long looked upon as the safeguard of the miner."

In 1879 Messrs. William Smethurst and James Ashworth communicated to the Manchester Geological Society an account of the elaborate series of experiments made by them at various times in the presence of large numbers of mining engineers, colliery managers, and others, at Brynn Colliery, Lancashire, with fire-damp direct from a blower in the Wigan Six Feet (9ft., or Trencherbone) mine. These experiments showed that various lamps passed the flame in certain currents, some withstanding it for a longer time than others, the Davy passing it at velocities varying from 360 to 600 feet per minute, depending on velocity, &c.; the Scotch gauze lamp, 180 to 600; the Clanny, 400 to 600; the Stephenson in a few tests went out; but in the Williamson, which is constructed on the same principle, flame passed at 450. Others, as recorded in the Transactions, stood 600, and in some the light went out.

They showed also that the ordinary lamp shield encircling about two-thirds of part of the lower gauze is no safeguard at all, and that a cylindrical glass shield encircling the whole only becomes a safeguard when it overlaps the top or cap gauze to the extent of half an inch more. In acknowledgment of the services rendered to the mining community

by these experiments, Mr. Smethurst, then an ordinary member of this Society, was elected a free life member.

Similar experiments have also been made by Mr. Rhodes, at Barnsley, and by Mr. Green, at Celynen Colliery, where in 1883 and for some years prior thereto the lamps to be used on each shift have been tested in an explosive current.

In 1876 and at other times experiments have been made by the Belgian Government.

The Accidents in Mines Commission visited Brynn Colliery and made experiments with Messrs. Smethurst and Ashworth's apparatus, and afterwards at Woolwich and elsewhere.

The Commission reported in 1886 that, "It has long been known that if the atmosphere becomes inflammable the Davy and Clanny lamps, and in less degree the Stephenson lamp, are unsafe in currents having velocities much below those encountered in well ventilated mines. Our experiments fully confirm this. The ordinary Davy lamp becomes unsafe before a velocity of 400 feet per minute is attained. The ordinary Clanny lamp will almost certainly cause an explosion in a current having a velocity of 600 feet per minute. A Stephenson lamp will frequently cause an explosion in a current with a velocity of 800 feet per minute."

My own annual reports, long ago and recently, have reported explosions of fire-damp in mines by passage of flame through the gauze of the Davy.

The testimony, therefore, of Sir Humphrey Davy himself, Select Committees of the Houses of Lords and Commons, Mining Engineers, Mining Institutes, and the Commission, have all shown that the Davy and other lamps are not safe in certain currents which are met with in certain mines. The Coal Mines Regulation Act, 1887, now requires that on its commencement 1st January, 1888, safety lamps shall

be so constructed that they may be safely carried against the air current ordinarily prevailing in that part of the mine in which the lamps are for the time being in use, even though such current should be imflammable.

Conclusion.

It thus appears that progress in geology and mining has been gradual, and more by the development of original principles than in making new discoveries. Also that geology was at first studied more as a collateral branch of mining than as a science in itself.

The very earliest writers, as I have shown, record that mining was practised, and that according to Agricola in 1556, the main principles were then understood, and also the dressing and smelting of ores.

The old process of proving ground by boring with rods and a spring pole is still practised, but within the last fifty years, the rope with steel cutters, and the hollow rotating rods with the diamond crown, have expedited the process and enabled depths previously supposed inaccessible to be reached, and very much better cores of the strata to be brought to the surface.

The landing, tipping, and dressing of minerals are subjects in themselves. Suffice it to say that improvements are being made almost from day to day, chiefly in the extended use of machinery.

The pick, hammer, and wedge remain as of old, with improvement in the wedges.

Machines for cutting coal and some other minerals have been introduced, and are a partial success.

Drills continue as of old, but machine drills worked by hand and by compressed air are also used, and when suited for the ground to be pierced they greatly expedite work and lessen labour.

Softening rocks by fire has disappeared. Gunpowder

succeeded. Now there is compressed or bobbin powder, and high explosives under various names, and for gaseous mines the high explosives in the Settle's and other water cartridges. There is also the probability of explosives coming into use which without the addition of water will not inflame fire-damp.

Sinking shafts is chiefly done as of old. Sinking with guides and a loose carrier was being practised when I came to Lancashire in 1850. The combined arrangement, by Mr. Galloway, of the carrier and the movable scaffold quickens the progress of the work and makes it safer. There is also the Kind-Chaudron process, for ground highly charged with water, which is done from the surface, like boring.

Instead of the strata sunk through in collieries being often left naked as of old, with stones not unfrequently falling therefrom, modern shafts are nearly all cased or lined throughout.

Wooden casing or tubbing and stone with cement work, to keep back water, the commencement of the use of which cannot be fixed, are still used. Iron cylinders were afterwards introduced, and then the making of them in segments introduced by Mr. Buddle; which was followed in 1845, by Mr. Arthur Anderson, introducing iron cylinders into the rock salt mines of Northwich.

The generation of steam is now greatly economised by improved boilers; and every boiler, whether it is worked alone or as one in a range, must have a proper steam gauge and safety valve, and also a water-gauge to show the exact height of water; and nearly every one has a mouthpiece or a strengthening rim round the manhole, which was not so 37 years ago, and by means of which explosions have been much lessened in number.

The steam engine has come into use since Agricola's time, and now, instead of single winding engines a pair

ıpled together is preferred, and each engine or pair of gines must have an indicator to show the position of the ıd in the shaft, which was not obligatory in 1850.

Winding drums and pit head pulleys have greatly ıreased in size, and ropes when requisite are counterpoised ıher by means of conical or spiral drums, or by balance pes underneath, as with chains in the old water-balance ts, or by a continuous rope on what is called the Koepe stem.

For winding. Hoop iron rivetted together into bands hich was used for winding on inclines in Lancashire until ter 1850, and prior to that time in shafts, has disappeared.

Single linked chains are still used as coupling chains, and r various purposes, but have long been forbidden by the ining Acts for winding men in shafts.

Double and treble linked flat chains, similar to what were ed in 1556, and commonly used in an improved form in affordshire in 1850, are still allowable for winding men.

Hemp, which was so long the favourite material for rope, is gradually given place to wire, even at rock-salt mines here iron is more liable to rust.

Iron wire ropes, which to a great extent supplanted mp, are now in turn giving place to steel.

Endless chains which in Lancashire after 1850 were used r winding coal from fully 200 yards in depth, and were referred for the regularity in delivery of tubs, are but tle used now and only for shallow depths.

Open shafts, a few only having iron guide rods fifty years go, in which the basket or corf for winding coal, and chain ops in which men each put a leg and rode in groops and ers like a string of onions, have now disappeared at deep ines; and in shafts, some fitted with guides made of iron ds for moderate depths, and wooden conductors or wire pe for any length, the descent and ascent is now made in

cages with safety and comfort at speed varying to the rate of about thirty miles an hour.

In the shafts at some metalliferous mines and some coal mines on the continent, the Fahrkhunst or man engine, with movable rods, like pump rods, and platforms affixed, have superseded the laborious work of climbing by ladders, and at a few shafts men ride in the skip.

The original safety catch, invented by Fourdrinier, for catching the load in the event of breakage of the winding rope, has long since disappeared on account of its catching at times without breakage having occurred; but with wooden conductors the safety catch on Owen's principle, the patent right of which has long ago expired, is used extensively in the Manchester district and is found to work safely and well.

Safety hooks or apparatus for disconnecting the load and catching it before reaching the pulley, in the event of overwinding, are becoming common; and when attended to and kept in order, and the speed on reaching the hooks is slow, are found to answer the purpose intended.

Wooden pump trees, as used in the sixteenth century, and still used to some extent, have been almost entirely superseded by iron, even for brine; but where water is saturated with acid which affects iron, as in some copper and iron pyrites mines, where iron rails must be kept clear of water, the iron pump trees are cased with wood.

Engines below ground are numerous, and are worked by steam generated either in the mine or piped down the shaft. Air engines are also worked below ground, the compression being generally done above ground. Power is also conveyed down the shafts by means of single ropes and endless ropes, and for shallow depths by rotating rods.

For conveyance.—Barrows and sledges with wheels running on the ground in 1556 were afterwards made to

n on prepared ways. Wooden rails were introduced, then
ım rails, and ultimately the edge rail. Rolleys carrying
rves, have given place to the tub waggon made of wood or
›n; and above ground the old chaldron waggon (except in
ırthumberland and Durham) is substituted by the railway
ggon, but the old North of England gauge of 4 feet 8½
:hes is still the standard, except in Ireland.

Horses are still numerously employed in mines, and are
nerally sleek and glossy.

Mineral is extensively conveyed below ground by
chinery with single rope, chain, tail rope, endless rope,
lless chain, gigs or self acting inclined planes, and by
line worked by windlass.

In thin seam mines, where there is difficulty in making
› travelling ways high enough for persons walking, even
a stooping position, and where the distance is long, as in
ne of the Lancashire mines, each man has his four-wheeled
dge or tram without sides, on which he rides to and from
place of work, and it is a curious sight to see one or two
ndred persons riding each on his own tram at quick speeds,
to see all the trams put up when work is over.

Disallowing boys between 10 and 12 years of age from
rking in these thin seams, may, it is apprehended,
uriously affect the obtaining of trained miners for such
ıms, it being found requisite to accustom the muscles to
› work when persons are young. Possibly something may
done by increasing the height of the roadways.

Working coal by wide work or long-wall has become
nmon in districts where fifty years ago it was considered
ıpplicable, and in very deep mines few permanent road-
ys are made without packing or stowing at each side
ıich receives the pressure and leaves the roadway free from
as if in the centre of a pipe.

Over-cutting, called stoping, or stooping—that is, working

in veins or steep seams so as to allow the mineral to fall where that system is found economical, has to a great extent superseded under-cutting, but not with the same advantage of securing the roof against falls of rock or mineral.

Rubbish for stowing is occasionally taken into the mine from above ground.

Spades with the handle and shovel cut out of solid oak or other hard wood, occasionally found in very old workings and attributed to the Romans, or pre-historic, are a thing of the past for mining.

Hoods, to enable the wearers to enter dangerous gases, and lamps for lighting, by means of air to be either carried or piped, referred to by the Lord's Committee in 1849, and afterwards, have had another invention added of compressed oxygen gas and lime by M. Fleuss, in which the breathing and lighting medium is oxygen gas. None of these have, however, as yet come into common use; but divers with suitable dresses and appliances are occasionally employed in mines, especially for going under water when pumps have become disarranged.

Record plans and sections of abandoned mines have now to be deposited in the Home Office, Whitehall, where for the first ten years they are private, unless with consent of the owners, after which time they are available for public inspection.

Swing doors, hung in the roof or placed in a recess at the side, for replacing quickly doors that might be blown out by an explosion, as recommended by Mr. Buddle, have been and are occasionally used, but are not common.

Tarpaulin, some of it non-inflammable, is extensively used for bratticing air forward instead of wood, and for air screens instead of doors.

For air screens, strong leather is occasionaliy substituted for tarpaulin, and with casing at each side to prevent air

escaping when the screen is being lifted is very durable, and well adapted for self-acting and engine planes.

Safety lamps of improved construction and more illuminating power, such as the Mueseler or Belgian lamp, and the Protector, have been in use for some years past, and afterwards in 1883 the Marsaut came into general use at the Altham Colliery, in Lancashire. These and similar lamps are rapidly supplanting the Davy, the Stephenson, and the Clanny, except that the Davy is still preferred by many persons for testing.

The test of withstanding the current of air ordinarily met with in the mine, even if it be explosive, required by the Coal Mines Regulation Act, 1887, will necessitate great changes in lamps. The Stephenson will perhaps be difficult to modify. The Clanny will have to be bonneted, and apparently a double gauze added for some currents. The Davy will require in such currents either the tin can, the encircling glass cylinder up to and a little above the cap or smoke gauze, and in some currents it may be a double bottom gauze in addition.

The electric light is now used at a few collieries for lighting near the shafts, and the portable electric safety lamp is used in a few, but an increasing number, of instances. The latter are made to burn about ten hours, and it appears that before becoming exhausted ample warning is given by a change in the colour of the light. For drawing props and other work requiring a good light, this lamp seems very valuable. The mode of using the lamps is easily learned, one of the principal precautions enjoined being that they should be kept charged when out of use.

Fire-damp indicators have been invented and tried, but cannot be said to have come into practical use.

The light in the electric safety lamp being enclosed in a vacuum, will need some supplementary appliance for testing,

and possibly some of the present indicators may become practically available. Meanwhile there are safety lamps which give light and at the same time afford an admirable practical test of the state of the air.

Measuring the velocity of air currents was formerly done by measuring the velocity by powder smoke, or by balloons, or by carrying a candle in the current so that the flame burns upright, the latter method being still commonly practised as a rough test.

Anemometers are now in common use. The first two that came under my notice nearly half a century ago were the Biram and the Combes, both being on the windmill principle, and required timing. Several others are also used, namely, the Robinson, Parke, Devillez, Prestal, Wolfus and Dickinson, some of which do not require timing. A description of these is given in this Society's Transactions, 1875. For comparative observations it is found best to set the anemometer on one fixed spot where there is an average velocity.

The old practice of increasing the ventilating power when the barometer reached a certain depression and during south east winds, or wet or hazy weather has to a great extent been superseded by systematic surplus ventilation rendering atmospheric influences comparatively inappreciable. No instrument has yet been found to show the change of pressure so quickly as the issue and expansion of gas, and it has been proved by experiments and observations that increased issues of gas occur simultaneously with the commencement of decreasing pressure, and not so much afterwards, which renders the issuing of what are called "colliery warnings" too late for practical use.

The effects of coal dust in aggravating explosions, which I think Mr. Buddle was the first to notice publicly, is now more generally recognized.

A system called panel working was introduced by Mr. Buddle in fiery mines, by which one panel or division could be shut off from the other parts of the mine when worked out, provision being made for the outlet of gas by a special drift for the purpose, the principle of which is still at times followed.

In parts of the kingdom, notably in Lancashire, drivings are made to the extremities which act like drains for firedamp, and otherwise minimise difficulties by enabling the coal to be worked back towards the shafts.

Gas drifts, driven near the top of a thick seam for draining firedamp in opening out were strongly recommended by Mr. Ryan some years ago, and are to some extent practised, but have scarcely become a system.

Outlets for gas on the rise side of goaves are systematically practised in the steep mines of Lancashire, and when not provided, the difficulty and danger of dealing with firedamp is found to be greatly augmented.

The coursing of air through the driven boards and ends, or rooms, or stalls, by which ever name they are known, as introduced by Mr. Spedding, has fallen into disuse, except by scalage or leakage of air in the direction of the ventilation, the main currents being taken along the faces only. The absence of systematic ventilation in these wastes, which may not be visited daily, is a source of anxiety, and has had to be closely scrutinized when some explosions have occurred in mines worked on this system.

Whether it is expedient or not to attempt to ventilate goaves or other inaccessible portions of the mine is a moot point. The common opinion seems to be that it is safest to ventilate when it can be thoroughly effected, but not to attempt such ventilation where it may only bring the gas to the explosive point. Opinions also vary as to whether with unventilated goaves it is safer to

course air in so far as practicable, or as each working becomes finished to shut the goaf off by packwalling. The advantage claimed for sending air in is that gas is kept at a distance from the working faces; and the advantage claimed for shutting off is that falls of roof in the goaf only stir gas about without driving much out into the working parts. Solid filling is considered best where there is rubbish enough for the purpose. In fiery mines which are not level an airway at the rise side of the goaf to receive the drainage of gas is considered indispensable in some districts.

Rendering fire-damp innocuous by chemical change as fast as it is discharged or as it approaches lights, as hoped for by Mr. Buddle, is still unaccomplished, but the ventilating power and size of airways which were then considered at the maximum have been so increased in size and power that the amount of ventilation is such that now it is only in the most fiery mines where gas is not swept away as it issues without any firing in the safety lamp or showing the blue cap.

For ventilating power, small fans are still used, but many large ones are now fully 40 feet in diameter.

Air pumps on a large scale have been tried, and a few are still in use, but owing to the loss in power in changing stroke, and the air current produced being intermitting, they have to a great extent been superseded by continuous ventilators such as fans.

The ratio of deaths by explosion in 1851 was one in every 673 persons employed. In the ten years ending 1861 it was one in 1008; in the second ten years ending 1871 one in 1408; in the third ten years ending 1881 one in the very much larger number of 1795; and the ratio of improvement is still progressing.

The ratio of deaths by accidents from all causes in and

about mines under the Coal Mines Acts is similarly favourable. It was in 1851 one in 219; in the ten years ending 1861 one in 245; next ten years ending 1871 one in 300; third ten years ending 1881 one in the very much larger number of 425 persons; and in the succeeding years the ratio is still more favourable, the ratio of loss of life being now only about one-half of what it was formerly.

The actual number of lives lost by all causes in and about mines under the Coal Mines Acts during the 36 years ending 1886, as shown by the statutory returns made to Her Majesty's Inspector of Mines, is 38,172.

The Coal and the Metalliferous Mines Acts now regulate all leading features in mining, except that, so far as I know, criminal offences still exist under 7 & 8 George the Fourth, c. 30, sec. 6 & 7, and under William the Fourth and 1 Victoria, c. 89, sec. 6, as to water and damage and setting mines on fire.

The rules and regulations under the Acts have to be posted up where they may be conveniently read, but much that cannot be legislated upon still depends almost entirely on the skill, care, and judgment of those most concerned.

Under the Society called the Order of St. John of Jerusalem, and other auspices, workmen are now trained to ambulance and 'first aid' duties, whereby much alleviation of suffering is afforded to persons injured in and about mines.

Funds for the relief of widows and orphans of colliers, and others who may lose their lives in collieries, and for the support of such as are maimed and disabled, as proposed for the collieries on the Tyne and Wear by Mr. Buddle in 1814, are now established in various districts, and the number of members is said to amount to about a quarter of a million.

Additional Mining Schools have been established, as recommended by some of the Committees, thus bringing the

aid of science in addition to that of practical experience which can alone be obtained in the mine.

Waste in working, pointed out by the Coal Commission in 1871, has in some respects been remedied, but much remains yet to be done; and apparently still requires the legislative enactment which the Commission hesitated to suggest.

I have no doubt but that in this address many important points in the progress of geology and mining are not mentioned, but being only an outline, omissions must be excused; and I hope that the omissions, together with what I have only alluded to cursorily, may afford opportunities for other members to give more amplified Papers to this Society.

Professor Boyd Dawkins moved a vote of thanks to the President for his very able and interesting address, which was seconded by Mr. Hall, and passed unanimously.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XIX. SESSION 1887-8.

The ORDINARY MEETING of the Members was held on Tuesday, December 6th, 1887, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOSEPH DICKINSON, F.G.S., &c., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary members of the Society, namely :—

THOMAS OLDHAM, Holmefield, Sale.

GEORGE H. HALLAS, Mining Engineer, Wigan and Whiston Coal Company, Limited, Prescot.

The following are the recent additions to the Library :—

Bristol Naturalists' Society : Proceedings, Part 2, Vol. V., N.S.—*From the Society.*

Edinburgh Geological Society : Transactions, Part 3, Vol. V. ; Catalogue of Library.—*From the Society.*

Essex Naturalist : Nos. 9 and 10.—*From Essex Field Club.*

Hertfordshire Natural History Society : Part 7, Vol. IV.—*From the Society.*

Leicester Literary and Philosophical Society: Transactions, Parts 4 and 5.—*From the Society.*

Liverpool Geological Association: Transactions, Vol. VII., 1886-7.—*From the Association.*

London—Royal Society: Proceedings, No. 258, Vol. XLIII.—*From the Society.*

——— Geological Society of London: Quarterly Journal, Nos. 164, 169, 172; List of Members, November, 1887.—*From the Society.*

——— Geological Magazine: Nos. 281 and 282.—*Purchased.*

Manchester Association of Engineers: President's Address; Pamphlet, by W. H. Bailey.—*From the Association.*

Midland Institute of Mining Engineers: Transactions, Parts 90 and 91, Vol. XI.—*From the Institute.*

Newcastle-upon-Tyne—North of England Institute of Mining Engineers: Transactions, Part 4, Vol. XXXVI.—*From the Institute.*

Oxford—Catalogue of Transactions, &c., in Radcliffe Library, 1887.—*From the Library.*

Scotland—Mining Institute of Scotland: Transactions, Part 5, Vol. IX.—*From the Institute.*

South Wales Institute of Engineers: Proceedings, No. 4, Vol. XV.—*From the Institute.*

Organization of Fossil Plants of Coal Measures: Part 13, by Prof. W. C. Williamson.—*Presented by Author.*

Canada, Toronto—Canadian Institute: Proceedings, No. 1, Vol. V., 3rd series.—*From the Institute.*

U.S.A., Cambridge—Harvard College: Bulletin of Museum of Comparative Zoology, No. 5, Vol. XIII.—*From A. Agassiz.*

——— Denver—Colorado Scientific Society: Proceedings Part 2, Vol. II.—*From the Society.*

——— Philadelphia—Franklin Institute: Journal, Nos. 742-743, Vol. CXXIV.—*From the Institute.*

——— Washington—U.S. Geological Survey: Sixth Annual Report, 1884-5.—*From Director of Survey.*

——— Shenandoah—The Colliery Engineer, Nos. 1, 2, 3, Vol. VIII.—*From Editor.*

Australia, Melbourne—Report of Registrar; Goldfields of Victoria, 30th June, 1887.—*From the Government.*

Berlin—Zeitschrift Deutschen Geologischen Gesellschaft: Band 39, Heft II.—*From the Society.*

Lausanne—Bulletin de la Société Vaudoise: No. 96, Vol. XXIII.—*From the Society.*

Paris—Revue de la Legislation des Mines, July-August, 1887.—*Purchased.*

Pisa—Atti della Società Toscana di Scienze Naturali: Memorie, Vol. VIII., Fasc. 2.—*From the Society.*

Rome—Atti della Reale Accademia dei Lincei: Vol. III., Fasc. 4–5.—*From the Academy.*

IMPROVEMENT IN SAFETY LAMPS.

Mr. STIRRUP, Hon. Secretary, said he had received from Mr. William Wood, of Levenshulme, a communication in which the writer said that he had invented and patented an important improvement in miners' safety lamps. His object had been to find some simple means of instantly extinguishing a lamp in case of its being brought into the vicinity of explosive gas. It consisted of an extinguisher or hood, held over the flame and supported by a rod or float dipping into a column of mercury. This mercury, becoming expanded by the extra heat imparted to the wire gauze, raises the rod and permits the extinguisher to fall over the flame of the lamp and thus to extinguish it. The improvement was applicable to all classes of miners' lamps, and was not costly. Permission was granted to Mr. Wood to exhibit a lamp fitted with his patented improvement at the next meeting of the Society.

THE BRITISH ASSOCIATION.

Mr. STIRRUP stated that, since the last meeting of the Society, the following note had been addressed to him, as Secretary, and delegate of the Society to the last meeting of the British Association:—

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

22, Albemarle Street, London, W.,
November 19th, 1887.

Sir,

Herewith I beg to submit a copy of the Report of the Proceedings of the last Conference of Delegates of Corresponding Societies, together with a list of the Committees appointed at Manchester. I will ask you to bring the Report under the notice of your Society at an early opportunity; and at the same time, if there should be any Committee on the accompanying list in whose work your Society, or individual members thereof, would be willing to render assistance, I should be glad if you would give information to this effect to the Secretary of the Committee or to myself.

You will find enclosed with the Report a copy of the Rules relating to Corresponding Societies, and a list of the Corresponding Societies at present on our list. Additional copies of the Report can be had on application.

I am, Sir, yours obediently,

R. MELDOLA,
Hon. Sec. Corresponding Societies Committee.

To the Secretary of the Manchester Geological Society.

It would only be necessary for him briefly to refer to the several documents. There was amongst them a list of the Committees of the British Association, about 73 in number, which had been formed for carrying out investigations in physical, meteorological, chemical, geological and biological science, the majority of which however do not fall within the range of our Society's work. He had called the attention of the members to this subject on previous occasions—and, more specifically, in the circular calling the present meeting—where were enumerated the special committees which they might, perhaps, be in a position to assist. Those committees were the Underground Water Committee, the Erratic Blocks Committee, and the Rate of Increase of Underground Temperature in Mines, &c., Committee.

The report of the Conference of Delegates contained one r two paragraphs in which, he thought, the members would e interested. One referred to a newly-formed committee, hat of Earth Tremors. This had been taken up for investiation by the North of England Institute of Mining and fechanical Engineers, and he hoped that some of the nembers of the Manchester Geological Society might see heir way to assist in the inquiry.

"Professor Lebour stated that the subject of Earth Tremors, which he had brought forward at the Conference of Delegates last year at Birmingham, had since taken a more practical shape, and that it now seemed to be time that a Committee of the British Association should be formed for taking the investigation in hand. Through the advocacy of Mr. Symons, who was unable to be present at the Conference, Sections A and G had that morning agreed to recommend the appointment of such a Committee in conjunction with Section C, which would be approached next day. The work to be done was of a preliminary character, and its object was rather to inquire into the best methods of conducting observations on Earth Tremors than to actually cause such observations to be made. The North of England Institute of Mining and Mechanical Engineers had, since the Birmingham meeting, carried on a series of seismoscopic observations at Marsden in the county of Durham, and the daily results, extending over several months and compared with a barometric curve, were shown to the meeting in the form of a diagram by Mr. Walton Brown, the Secretary of the Newcastle Institute Committee. The Institute possessed also a more elaborate instrument, made after a pattern supplied by Professor Ewing, which registered the intensity and direction of the tremors. Professor Lebour stated that, although such instruments as the last mentioned were probably too costly to be placed at all desirable stations, this would not be the case with the simpler seismoscope, which recorded merely the fact of earth tremors having taken place and the time of their occurrence. Such records would be valuable though limited. The Corresponding Societies, if they would interest themselves in the matter, might be the means of establishing a great network of seismoscopes with a few seismographs in suitable localities, and results of value would by this means be in all probability obtained. These results would be valuable altogether in proportion as well-equipped seismometrical

observing stations were numerous. The expense must in any case be considerable in the aggregate, but need not be great in individual cases. A sufficiently good seismoscope might be had for about £2, a seismograph for £14 to £15, and the cost of keeping them in order would not be great. Professor Lebour hoped the Delegates present would help in establishing such a network of observing stations all over the country, and he stated, in concluding, that he would be happy to communicate with anyone interested in the subject.

Professor Ewing, in response to the Chairman, said that from his experience of earth-tremor observations in Japan, he could concur in the remarks of Professor Lebour. To investigate fully the character of the motion, even at one station, required delicate and costly apparatus, and the cost was greatly increased when it was attempted to bring a number of stations into correspondence so as to determine the motion over a large area. It was possible, however, to record the fact that a tremor had occurred, and even to learn something of its character by means of inexpensive seismoscopes; and it certainly seemed to him that no bodies could more appropriately undertake that work than the local Societies represented at the Conference acting in conjunction with a Committee of the Association. From recent observations it appeared probable that tremors would be found wherever they were tested for with sufficient delicacy, so that a Society undertaking the search was not likely to be disappointed."

At the second meeting of the Conference, Professor Lebour stated that the formation of a joint committee, by Sections A, C, and G, had been agreed to, and the following resolution forwarded to the Committee of Recommendations:—

That Sir F. J. Bramwell, Mr. E. A. Cowper, Mr. G. J. Symons, Professor G. H. Darwin, Professor Ewing, Mr. Isaac Roberts, Mr. Thomas Gray, Dr. John Evans, Professor Lebour, Professor Prestwich, Professor Hull, Professor Meldola and Professor Judd be a Committee for the purpose of considering the advisability and possibility of establishing in other parts of the country observations upon the prevalence of earth tremors, similar to those now being made in Durham in connection with coal-mine explosions, and that Professor G. A. Lebour be the Secretary.

(*This resolution was afterwards adopted by the General Committee.*)

The PRESIDENT said: Without much expense in the chase of instruments we might, through our members, her some useful information upon this subject. There e been some earthquakes recently in foreign countries ch have caused the loss of many lives, and rendered ge numbers of people homeless: without referring to se serious cases, which have apparently no relation to work of man, it would be interesting to know how those earth-tremors in the neighbourhood of Sunderland, instance, are connected with the pumping of water n the Magnesian Limestone. Then, again, these earth-kes which we are said to have had recently in Lancashire r be due to old coal workings. Chorley, it is well wn, stands entirely upon pillars. Parts of Bolton, also, undermined by old coal workings, as I ascertained m on the coal commission. On these points much ful information might, no doubt, be collected by the iety.

Mr. STIRRUP: I think this Earth-tremors Committee is we certainly could aid, if the colliery owners and nagers would take the matter up. It is a very interesting ject; but the Committee's investigations do not refer so ch to earthquakes which are felt on the surface as to se imperceptible earth-tremors which require very deli- instruments for their observation. Professor George Darwin, of Cambridge, was the first, I think, to call ntion to them. He said that the earth's crust was loubtedly in a state of continual vibration, and one of the stions for consideration was, how far beneath the surface se earth-tremors extended, or whether they were only sible on the surface. He could not but think that such estigations would be of interest to miners.

Mr. BURROWS: Do not you think that, in ordinary coal- so many disturbances are due to actual working of the

coal—especially in wide work—that such observations would be scarcely reliable ?

The PRESIDENT: Particularly where their are old workings overhead, which are liable to get disturbed by subsidence, or by pumping.

Mr. STIRRUP: I have not read the report of what has been already done by the North of England Institute, and therefore cannot say how far these objections were found to weigh with them.

Mr. WATTS: If it was thought desirable that the Society should possess one or more of these delicate instruments, to which the Secretary had referred, he, as living outside the coal area, would be glad to take charge of one, and give the Society the benefit of the readings.

RICHMOND COAL-FIELD, VIRGINIA.

By Mr. William Clifford, M.E.

From the swamps at the head waters of the Chickahominy river, North West of Richmond, Virginia, there extends in a direction (about 15 S.W.), for a distance of over 30 miles: a coal-field which has been known and worked since the commencement of the 18th century. It supplied fuel for the smiths' forges at the time Cornwallis' army lay in its camp at Genito on the Appomattox. It it also said to have supplied fuel to a cannon foundry in Richmond, during the American Revolution.

Long before the log foundations of Fort Pitt,—where Pittsburg now stands—were laid, or the hunter Phillip Ginter discovered Anthracite on Bear mountain; coal mining was actively—and then so termed—extensively carried on at Midlothian, 13 miles from Richmond.

To-day, as you travel through the woods, which cover the face of the country, the one thing that excites surprise is the great number of pit-hillocks, and little square holes, or shafts, lined with timber—mostly full of water—and all unfenced. In some places these pits thickly stud the ground like bell-pits in a shallow ironstone working in England 30 years ago. If you examine the hillock material lying about some of the deeper shafts, you will find, side by side, limestone from the lias, and granite from troubles in the coal; together with coarse grained stone, having parallel beds, but the appearance of granite generally with an excess of hornblende:—many grades of coloured micaceous shale, from a deep purple to a bluish white, and occasionally a fossil fern or shell. You come across a dismantled engine-house; a drum or a pulley wheel lying about here-and-there; a disused T bob, a broken pump tree, or an old boiler, far away from any sign of life or activity—save the activity of insect life, and the ceaseless clang of the bull-frog. The grass-grown formation of a railway is the only indication that these things ever had any connection with the outer world. The only trace that now remains of the celebrated Black Heath pits, is a large pond or swamp, literally alive with snakes. It was here that Sir Charles Lyell mentions descending a shaft 800 feet deep, and having seen coal taken out 40 feet thick, and "like the finest quality shipped at Newcastle" (Manual p. 285). At Midlothian, three years ago, two feeble affairs were still in operation, one working natural coke; and the other working coal from the old Etna shafts. Deep Run was closed—fully worked out. The Tuckahoe basin was dead, and the railway to Carbon Hill pulled up. Two little places were working on the south side of the James river, near Sabots' Island,—one owned by Manchester men. Clover Hill, in the southern part of the coal-field (which the writer believes,

has never really stopped), was working with a promise of increased capacity and apparent success. With these exceptions the appearances everywhere, were of a coal-field worked out, with the accompanying gloom and poverty among those colliers, who lacked the opportunity or enterprise to push out elsewhere. Yet, so far from this being the case, only the most sketchy outline of the field has been touched. Of the 180 square miles contained within its boundaries, less than two square miles have been worked, and probably less than half of the coal got out of that area. The total output from these pits since the commencement of this century is said to be about 5,000,000. The writer believes it is less.

The coal-field ranges from 12 miles N.W. of Richmond to about 24 S.W., extending into the counties of Goochland, Henrico, Powhatan, Chesterfield, and Amelia; and traces of coal have been found in Hanover County in the vicinity of Ashland, and further north and west; while, in the most recent hand-book issued by the Commissioner of Agriculture for Virginia, it is stated that coal has been found in Dinwiddie County—a statement which does not at all surprise the writer.

The northern end of the coal-field at Springfield is tapped by a branch of the Richmond, Fredericksburg, and Potomac Railroad from Hungary Station; and the Richmond and Danville Railway strikes the coal-field on its eastern boundary near Midlothian, about 13 miles from Richmond, crossing it diagonally in a south-westerly direction. Formerly there was a coal railway worked by mules from the collieries at Midlothian to the James River opposite Richmond. It was over this railway that the gas coal was carried for shipment to New York and Philadelphia, as mentioned by Sir C. Lyell at the time of his second visit in 1844. The Clover Hill Railway, now called the Brighthope

ilway, has been extended to Epps' Falls on the
pomattox River three miles south of the collieries on the
› hand; and, on the other, from Chester to their shipping
iths at Bermuda Hundred on the deep water navigation
the James. Formerly the railway struck the James river
a place called Osbornes higher up; but since the making
the Dutch Gap Canal cut off the bend on which Osbornes
situate, that part of the river has been silting up.

The outlines of the coal-field as delineated on Map Plate I,
g., I, accompanying this paper are those laid down by
›fessor W. B. Rodgers in his "Memoir," now in the Capitol
›rary at Richmond. Experience has proved that, from
area embraced within these outlines, a good portion
st be deducted for "troubles and pinches," in order to
ive at the true coal-producing area of the field. From
writer's observations and from the best information
ilable, he wonld be inclined to put down the deduction
ler this head at 20 per cent. of the whole area.

The greatest elevation in the coal-field is somewhat over
) feet above the datum of the United States coast survey,
urvey, so far as it extends, answering to our Ordnance
rvey. The streams rising within the coal-field have their
leys shallow and broad. Those of the two principal ones,
ift Creek and Falling Creek, narrowing and deepening
they enter the older formations in their course towards
nes River. Falling Creek, in a course of 10 or 12 miles,
ls about 300, passing in its lower course the same granite
ge that forms the falls of the James River at Richmond.
ift Creek, which drains the middle southern portion, has
›ut an equal fall, distributed over a distance of 20 miles.

There are no sharp prominences in the district; small
ft hills, presenting no steep declivities, stand out here
l there above the general plane of the county.

The occurrence of these coal measures is most interesting

and singular. They lie at the base of the "only oolitic rocks found in all the United States and Canada." They are deposited in a huge hollow, say 3,000 feet deep over 30 miles long and from 4 to 10 wide with a number of smaller hollows on each flank: all scooped out of the granite rock,—formed by the junction of ridges, whose summits are now planed away,—or by local subsidence of the fundamental granite. Sir C. Lyell says the latter.

In the main trough upon the granite floor, is now found a variable thickness of Triassic rocks sometimes over 500 feet thick. These form the bed upon which lie the coal measures consisting of coal seams, carbonaceous shales and sand stones. The rocks thin out towards the sides of the basin as though, during their deposition, the rock material had slid somewhat down the steep sides on which it was thrown down.

In the outlying basins there is found only one coal seam, usually of great thickness and separated from the granite by a thin bed of shale,—sometimes only a few inches thick.

It was necessary to sink into the granite to form a sump at the Greenhole shaft, and Sir Charles Lyell says of the Black Heath pit, that only two inches of shale divided the coal from the fundamental granite; that in some places even that had been removed by disturbance, which had taken place at some period subsequent to the formation of the coal and its superposed rocks,—numerous cracks being visible in the granite floor on the removal of the coals.

The coal measures alone contain the organic remains which enabled geologists to determine the age of the rocks, and identify them with the oolite of Whitby, Yorkshire, or more generally with the Jurassic formation of European countries.

Above the coal measures we have a series of rocks formed of the detritus of the adjacent older ones, often cemented in a calciferous matrix. The same thinning towards the edge (or

rather thickening towards the centre) of the basin, such as characterises the lower rocks is observable in these upper ones, so much so that the upper members near the centre of the basin appear as horizontal.

If we suppose the shell of a walnut to be turned inside out and lengthened in the direction of its longitudinal axes, we can form an exaggerated idea of the crumpled shape of the floor on which the coal rests. This is especially apparent in the detached basins with their granite floor. There seems nevertheless to be a series of wave-like longitudinal ledges or terraces, which separate the basin into more or less regular zones.

In the older collieries, working the detached basins, the writer is informed that owing to its great tenacity, the roof remained unbroken over large areas, laying bare remarkable configuration of roof and floor, disclosing numerous protrusions from the latter, sometimes with corresponding indentations in the former.

Lesley is of opinion that the great basin in which these coal measures lie got filled up with sand and mud from an estuary stretching through South-east Pennsylvania, Maryland and Virginia, having its capes at Trenton and Manhattan island. There is a most interesting epitome of his views reprinted in Macfarlane's "Coal Regions of America." Others with more circumstances hold the opinion that the water broke into the Richmond Coal basin over the low ground about the upper Pamunky river, near where Hanover Junction now is, and filled up the great cavity or valley to overflowing; and when we consider the positions of several streams and the structure of their valleys, it would seem that there existed depressions in the eastern edge of the basin, corresponding with the outlets of these streams; that portions of the current which overflowed at these points wore away the Eozoic lip, and in time cut the

deep gorges in the granite we now see on Swift Creek, and eroded the newly-formed rocks within the basin itself.

Several questions are suggested by the occurrence of this coal-field, but which *this* paper does not propose to answer except in the most general and incidental way. One—Was the material forming the coal seams transported? Others—such as—Was the coal deposited in the main basin at the same time as the detached ones? Why are there no interlying measures between the coal seams and granite in the detached basins?

One theory—which the writer has not seen in print, but has heard it verbally enunciated by its author—is to the effect that the Richmond coalfield is *not* continuous; or, more correctly, that there is no coal present in the deep portions of the basin. It may be here observed that Sir Charles Lyell, in his ideal section, shows the coal as thinning out to the dip both on the eastern and western outcrops—a faint dotted line through the centre of the basin, connecting the two attenuated sides. The theory referred to is that at some time, about this particular coal period, a strong current driving from the N.W. broke over the low ground in the vicinity of the upper Pamunky, as mentioned above, and swept through the basin in the direction of its length. That this current, whether the bearer of the material of the coal seams, or a denuding force acting on coal measures already in place, deprived the central part of the basin of its coal. That the large bosses, or projections from the sides, retained the floating carbonaceous matter in the still bays between them, in one case, or protected the already deposited coal from erosion on the other; but in either, leaving only a narrow margin of coal here and there.

The writer thinks that the transportation theory must be abandoned in this case. The opinion of every eminent geologist that has examined the district is that the

coal flora grew where the seams now lie. Sir Charles Lyell was very clear on this point. He considered the two inches of shale between the coal and granite at Black Heath represented the soil in which the coal plants grew. The writer would also call attention to the fact that, while all sedimentary rocks thin against the steep sides of the basin, the coal seams in the main basin are equally thick at the outcrop and in the deep. The tenacity of the roots having given the coal plants a firm hold up the steep sides of the trough.

Sir Charles Lyell says: "These last, the *Calamites* and "*Equisetum*, are very commonly met with in a vertical "position, more or less compressed perpendicularly. I "entertain no doubt that the greater number of these plants, "standing erect in the beds above and between the seams "of coal which I saw at points many miles distant from "each other, have grown in the places where they are now "buried in mud and sand, and this implies the subsidence of "the whole region."—[*Second Visit to the United States*, Vol. 1, p. 282.]

The writer is equally convinced that the assertion of sterility of the deep portions of the trough or basin,—based on the theory referred to, has no substantial foundation in fact. For any current of the magnitude and velocity conceived, must have entirely swept away all coal from the shallower basins like the Greenhole at Midlothian, and still shallower ones at Deep Run, before it could touch the central depth,—proved to contain coal at above a thousand feet below. But the fact the writer would rely upon most in support of his contention is, that at the south end of the coal-field where it narrows to four miles, and therefore any current moving lengthwise through the basin must have its scouring action greatly increased over what it would be where 10

miles wide; the coal is intact to the surface, and therefore it can but have suffered little, two or three thousand feet below. If we conceive of a granite ridge (now gone) separating the Greenhole basin from the main one at that period, it will not help us with Deep Run.

The foundation of this "removal" theory is the very doubtful and uncertain fact of a fine blue sandstone dyke having been found in place of the coal seam at the Bright Hope Colliery, Clover Hill, nearly a thousand feet from the surface.

The physical and chemical properties of the coal are those common to bituminous coals of this country. The only exception being where trap has intruded into the immediate vicinity of some seam; then we have the curious phenomenon of natural coke extending often over a large area.

The coal is bright. It breaks short and square, is very black, and in general appearance is like the Silkstone seam of Yorkshire and Derbyshire. It is very fatty and close caking. It contains iron pyrites in some places, often in cellular form, so that when the contained coal has crumbled away, by exposure to the weather, the pyrites somewhat resemble a honey-comb in shape.

The coal stands fairly well in pillars even where the seam is inclined at an angle of from 20 to 30 degrees.

It varies in hardness. The hardest coal is usually freest from impurities. That containing an excess of sulphur being very friable. Its specific gravity averages about 1·30. Various analyses show from 45 to 70 per cent. of fixed carbon; and, from 25 to 40 per cent. of volatile matter. Ash from 2 to 16 per cent.

Below will be found table of analyses :—

TABLE OF ANALYSES OF RICHMOND, VIRGINIA, COAL AND NATURAL COKE.

SOUTH OF THE JAMES RIVER.

Colliery.	Analyst.	Specific Gravity	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Coke.
Clover Hill (Coxe's)	Prof. Johnson	..	1·339	30·984	56·831	10·132	·514	66·963
Do. do.	W. B. Rodgers	..	..	29·12	66·52	5·36	..	70·88
Do. do.	G. W. Andrews	..	..	38·50	55·00	6·50	..	61·50
Do. Racoon	..	1·31	..	..	..	..	..	..
Stonehenge	W. B. Rodgers	..	..	36·50	58·70	4·80	..	63·50
Creek Company's Shaft	Prof Johnson	..	1·450	26·788	60·30	8·57	2·89	68·872
Mills, Reid & Co., Creek Shaft.	W. B. Rodgers	..	..	38·60	57·80	3·60	..	61·40
Greenhole Shaft	Do.	..	..	31·17	67·83	2·00	..	69·83
Midlothian (Average)	Prof. Johnson	..	2·455	29·73	53·01	14·73	·058	67·75
Do. New Shaft	Do.	..	0·67	31·20	56·40	9·44	2·286	65·84
Do. Screened	Do.	..	1·785	34·29	54·06	9·65	·202	63·71
Do. Grove	..	1·286	..	..	..	..	..	..
Do. 900ft. Shaft	Do.	..	1·172	27·27	61·08	10·46	..	71·55
Do.	Silliman & Hubbard	..	2·000	31·62	58·26	7·67	..	66·31
Do. 1875, Screened	A. S. McCroath	..	1·03	38·23	54·27	6·47	1·52	60·74
Do. Average	Do.	..	1·05	36·49	46·70	15·75	2·23	62·46
Maidenhead Pits	W. B. Rodgers	..	..	32·83	63·97	3·20	..	67·17
English Company, Old Shaft	Do.	..	..	35·82	53·36	10·82	..	64·18
Do. Middle Bench	Do.	..	..	28·40	66·50	5·10	..	71·60
Do. Top Bench	Do.	..	..	28·40	61·68	9·52	..	71·20
Chesterfield Mining Company	Prof. Johnson	..	1·896	28·719	58·794	8·634	1·957	67·42
Wills' (Ætna Shaft)	Clemson	..	..	28·80	66·60	4·60	..	71·20
Powhatan Pits (Col. Finney's).	W. B. Rodgers	..	..	32·33	59·87	7·80	..	67·67
Scott's Pits	Do.	..	..	33·70	60·86	5·66	..	66·52
Jewitt & Bro., Midlothian Natural Coke "Lustrous"	Dr. T. M. Drown	1·35	0·69	11·10	81·52	6·68	1·60	..
Do. do. "Dull"	Do.	1·375	2·00	15·47	79·33	3·20	4·08	..

NORTH SIDE OF THE JAMES RIVER.

Carbon Hill Bituminous Upper Seam	O. J. Henwich	..	1·40	20·60	60·80	17·20	..	78·00
Do. Second Seam	Do.	..	0·40	18·60	71·00	10·00	..	81·00
Do. Natural Coke	Do.	..	1·57	9·64	79·93	8 86	..	88·79
Do. Average	Prof. Johnson	..	1·785	23·95	59·97	14·28	..	74·25
Do. Natural Coke	Do.	..	1·116	11·97	75·081	11·82	..	86·90
Anderson's Pits (Dover)	W. B. Rodgers	..	..	28·30	66·78	4·92	..	71·70
Do. do.	Clemson	..	..	26·00	64·20	9·80	..	74·00
Coalbrookdale, 1st Seam	W. B. Rodgers	..	..	24·00	70·80	5·20	..	76·00
Do. 2nd Seam	Do.	..	..	22·83	54·97	22·20	..	77·17
Do. 3rd Seam	Do.	..	..	24·70	65·50	9·80	..	75·30
Do. 4th Seam	Do.	..	..	21·33	56·07	22·60	..	78·67
Cranches Upper Seam	Do.	..	..	30·00	64·60	5·40	..	70·00
Waterloo	Do.	..	..	26·80	55·20	18·00	..	73·20
Deep Run Basin	Do.	..	..	26·16	69·86	5·00	..	74·86
Carbon Hill Natural Coke	Dr. Wallace, of Glasgow	..	1·56	14·26	81·61	0·224	0·33	83·85

THE ABOVE HAVE ALL BEEN PREVIOUSLY PUBLISHED.

The largest yield of gas that the writer has heard of was 10,600 cubic feet per ton, obtained over 40 years ago in Philadelphia.

Natural coke was principally found in that part of the field lying to the North of the James river, but in 1882 it was found near the old Black Heath at Midlothian. There are two varieties got from the same seam; one heavy close-grained and strongly charged with sulphur, and other impurities; unequally and imperfectly carbonised. It has the property of exploding with a sharp crack and flying out of the fire, and is termed "popping coke." This property is so persistent as to render it unfit for household use.

The other variety got from higher in the same seam, and at Messrs. Jewitts, (Plate IV., Fig. 3) nearer to the trap, is more fully carbonised and somewhat resembles artificial coke. It is more spongy and lighter than the other. It makes a fairly good fuel for open grates and stoves, and is very easily mined.

This natural coke lies in the upper part of the coal measures, and has been mostly worked in the northern end of the field, where, instead of one thick seam as at Midlothian and further south, the coal is split up into a number of moderate-sized beds, divided by shales and sandstones. The coke is usually divided from the superposed trap, to which it owes its carbonisation, by a few feet of strata. At Messrs. Jewitt and Bros.' pit at Midlothian the division is seven feet of arenaceous shale. The trap is 2½ feet thick—quite conformable, but thin layers or masses are also intruded into the shales above and below the coke seam.

Near Carbon Hill the trap is said to be 10 to 55 feet thick, and the seam of coal lying 60 feet below is coked; while of the seam which existed a few feet above the trap there remains only ashes and cinders, with partly reduced

iron (*i.e.*, calcined pyrites) and wreckage from the overlying shale.

The measures which overlie the coke seams are very much fissured, and consequently the pits working coke are more heavily watered than coal pits. Some of the most promising ones in the northern end of the field had to be abandoned on that account.

For the section near Carbon Hill, Plate 4, Fig. 10, and for much general information, the writer is indebted to Mr. J. R. Werth, the present managing director of the Brighthope Railway and Clover Hill Collieries, whose father owned and worked some of the pits, and also accompanied Sir Chas. Lyell on many of his geological expeditions in this district. The detailed section of the coke seam at Messrs. Jewitt's pit, Midlothian, was taken by Mr. Jno. Blayden, an Englishman, formerly underground manager at Abercarne Colliery, of whose death the writer heard with great regret a few days ago. Speaking of this natural coke, Sir Charles Lyell says: "Before I "examined this region, I was told that a strange anomaly "occurred in it, for there were beds of coke overlying others "consisting of bituminous coal. I found on visiting the "various localities of this natural coke, that it was caused "by the vicinity or contact of volcanic rocks (greenstone "and basalt), which, coming up through the granite, inter-"sects the coal measures, or sometimes make their way "laterally between two strata appearing as a conformable "mass. As in the Durham coal-field in England (in Haswell "Collieries, for example), igneous rock has driven out all "the gaseous matter, and, where it overlies it, has deprived "the upper coal of its volatile ingredients, while its influence "has not always extended to the lower seams. In some "spots the conversion of coal into coke seems to have been "brought about, not so much by the heating agency of the

of strong heat are everywhere to be found in the upper coal measures. In some of the trial holes beyond the granite ridge West of Deep Run, the writer found a thick bed of quartz shivered by heat and upheaval.

The manner of working this coal has varied so much with men and places, that there cannot be said to be any particular system, but when the coal presented a virgin outcrop, an engine plane driven full dip of the seam, was the usual form of winning. When the outcrop had been previously worked a shaft was sunk, and if the rise workings were drowned, or on fire, the shaft was usually sunk into solid coal,—though, by mistake, the hollows were sometimes struck instead. Shafts, generally however, had for their object the doing away with a long haul over steep gradients, and thereby increasing the output of coal; and were therefore put down in positions which underground conditions showed to be most favourable. Many shafts are placed upon the flat of the ledges or terraces previously referred to, the colliery people of the day, fancying they had reached the bottom of the basin. This mistake was repeated many times over in different parts of the field, nearly always from want of any authentic records and plans of former workings in the locality. (In more than one case to the writer's knowledge, persons started to re-work pits that had already been worked out—generally on the recommendation of some sapient old collier.)

The usual result was—when the shaft was down they would drive a little distance level, strike the "pinch," or brink of the terrace and go further down the dip with an engine plane in the same direction as the one cut off by the shaft. Many fiery pits were worked by a single shaft, usually 10 or 11 feet square, divided by a strong board brattice. The pumps, if any, were put in the upcast section. The writer did not see a furnace anywhere in use, and he

views so well founded and supported by such authority, apparently on second-hand information; and characteristic rocks selected by persons without even a rudimentary knowledge of mining and lithology. There is abundance of trap in situ and lying about the pit bank. There are evidences of heat all round, beginning at the granite bared near the western outcrop of the Black Heath basin.

There has been practically nothing written which is the result of personal examination, by any geologist of standing, upon the geology of this region since the writings of Sir C. Lyell, with which the earlier notices of Professor W. B. Rodgers are in accord, but are not generally accessible.

PROXIMATE ANALYSIS (OF NATURAL COKE).

By Dr. Droon.

	Dull Portion.		Lustrous Portion.
Sp. Gr.	1·375	.....	1·350
Loss at 100c.	2·000	.....	0·69
Volatile Matter	15·47	.....	11·10
Ash (dark brown)	3·220	..(white)..	6·68
Fixed Carbon.....	79·33	.....	81·52
	100·00		100·00
Sulphur	4·08	.....	1·60

The writer would call attention to the fact that the sp. gr. of the coke is greater than that of the coal taken from seams not carbonized.

No pipe has been found and the irruptive point of the trap is not known, though the writer found a "dyke proper" coming to the surface near Buck Hill, S.W. of Midlothian, and where the coal would be at a great depth below. Commencing with the disturbed ground between Midlothian and the James river, travelling northward along the eastern outcrop, natural coke and evidences

than by any particular size of pillars. In the large basins that were formerly worked, pillars were 20 to 35 yards square. That is the levels, where practicable, were 20 to 35 yards apart (according to angle of dip) and bolt-holes 16 feet wide were driven from the lower to the upper level the same distance apart as the levels. The headings were ventilated by brattice until holed. In place of cloth, sawn boards were used, nailed to poles in the same manner as cloth, but requiring a good deal of keeping tight. A number of heads would be going in brattice in a short level at the same time. The writer did not see any regular system of pillar work anywhere, the number of projections and pinches not admitting of it on an extended scale. The greater part of the pits he saw stood on brattice. In one colliery, where a most serious explosion occurred, killing nearly 40 men, two cloths were hung in the engine plane (the trains passing through them every journey), to drive the air round the main workings, including at least half a dozen headings on brattice rising 25 degrees. In another pit the writer went into a heading where four men were at work. The place was a level about 15 feet wide and 7 feet high; gas showed 2½ inches of "top" on the men's open lamps, and one man stood at the lip of the brattice to prevent any person from taking a light to the rise side. In one colliery where a good deal of gas was made and the seam locally very thick, bolt-holes were driven down hill, a mule gin being used to haul out the coal. Self-acting planes, which are here called "drum-hills," are few in number. The pillars are worked when a level has reached the boundary or a "trouble" which is not desired to cut through. They are thinned or the term "robbed" best describes the operation of slicing them away so long as the roof can be kept up, and when that is no longer practicable, the coal remaining in them is left to give rise to or feed the gob fires which always follow in due time.

believes, that, until the advent of *fans* the collieries in Virginia depended entirely on natural ventilation; though hand-blowers were used for cases of emergency in special places underground.

In this Richmond coal-field the writer saw the only round shafts to be met with in America—the deep pits at Clover Hill, the old Etna shafts at Midlothian, and there is a very large one at Dover.

In one of the Clover Hill shafts used for winding water, the original brickwork had given way from creep and the wash of water from the tubs. Wood blocks, 18in. × 10in. × 5in. of second growth pine, were substituted with complete success.

Square shafts were lined with logs, notched or halved at the corners somewhat like the pits in Scotland, and when well backed-up were fairly secure. Experience has proved here that they will stand any blast that can take place with the feeble ventilation that obtains in the workings. The greatest source of danger to shafts in Virginia arises from "pillaging" the pillars, setting of creep, scarcely any of them are perpendicular. Some single shafts are much smaller than the area given. The deepest shaft sunk in the field is one near Midlothian not bottomed at 1022 feet, shown in Section Plate 3.

The Midlothian pumping shaft, at which there is a 60in. Cornish engine, erected in 1858, is 776 feet deep. One of the Brighthope shafts at Clover Hill is about 900 feet deep. There are no deep shafts north of the James River. The deepest workings in the field will be the dips of the Grove shaft, which the writer estimates at 1,200 to 1,500 feet from the surface.

The underground workings generally consist of one main engine plane, with levels on each side at intervals determined more by the regular or disturbed character of the ground,

deep gorges in the granite we now see on Swift Creek, and eroded the newly-formed rocks within the basin itself.

Several questions are suggested by the occurrence of this coal-field, but which *this* paper does not propose to answer except in the most general and incidental way. One—Was the material forming the coal seams transported? Others—such as—Was the coal deposited in the main basin at the same time as the detached ones? Why are there no interlying measures between the coal seams and granite in the detached basins?

One theory—which the writer has not seen in print, but has heard it verbally enunciated by its author—is to the effect that the Richmond coalfield is *not* continuous; or, more correctly, that there is no coal present in the deep portions of the basin. It may be here observed that Sir Charles Lyell, in his ideal section, shows the coal as thinning out to the dip both on the eastern and western outcrops—a faint dotted line through the centre of the basin, connecting the two attenuated sides. The theory referred to is that at some time, about this particular coal period, a strong current driving from the N.W. broke over the low ground in the vicinity of the upper Pamunky, as mentioned above, and swept through the basin in the direction of its length. That this current, whether the bearer of the material of the coal seams, or a denuding force acting on coal measures already in place, deprived the central part of the basin of its coal. That the large bosses, or projections from the sides, retained the floating carbonaceous matter in the still bays between them, in one case, or protected the already deposited coal from erosion on the other; but in either, leaving only a narrow margin of coal here and there.

The writer thinks that the transportation theory must be abandoned in this case. The opinion of every eminent geologist that has examined the district is that the

coal flora grew where the seams now lie. Sir Charles Lyell was very clear on this point. He considered the two inches of shale between the coal and granite at Black Heath represented the soil in which the coal plants grew. The writer would also call attention to the fact that, while all sedimentary rocks thin against the steep sides of the basin, the coal seams in the main basin are equally thick at the outcrop and in the deep. The tenacity of the roots having given the coal plants a firm hold up the steep sides of the trough.

Sir Charles Lyell says: "These last, the *Calamites* and "*Equisetum*, are very commonly met with in a vertical "position, more or less compressed perpendicularly. I "entertain no doubt that the greater number of these plants, "standing erect in the beds above and between the seams "of coal which I saw at points many miles distant from "each other, have grown in the places where they are now "buried in mud and sand, and this implies the subsidence of "the whole region."—[*Second Visit to the United States*, Vol. 1, p. 282.]

The writer is equally convinced that the assertion of sterility of the deep portions of the trough or basin,—based on the theory referred to, has no substantial foundation in fact. For any current of the magnitude and velocity conceived, must have entirely swept away all coal from the shallower basins like the Greenhole at Midlothian, and still shallower ones at Deep Run, before it could touch the central depth,—proved to contain coal at above a thousand feet below. But the fact the writer would rely upon most in support of his contention is, that at the south end of the coal-field where it narrows to four miles, and therefore any current moving lengthwise through the basin must have its scouring action greatly increased over what it would be where 10

miles wide; the coal is intact to the surface, and therefore it can but have suffered little, two or three thousand feet below. If we conceive of a granite ridge (now gone) separating the Greenhole basin from the main one at that period, it will not help us with Deep Run.

The foundation of this "removal" theory is the very doubtful and uncertain fact of a fine blue sandstone dyke having been found in place of the coal seam at the Bright Hope Colliery, Clover Hill, nearly a thousand feet from the surface.

The physical and chemical properties of the coal are those common to bituminous coals of this country. The only exception being where trap has intruded into the immediate vicinity of some seam; then we have the curious phenomenon of natural coke extending often over a large area.

The coal is bright. It breaks short and square, is very black, and in general appearance is like the Silkstone seam of Yorkshire and Derbyshire. It is very fatty and close caking. It contains iron pyrites in some places, often in cellular form, so that when the contained coal has crumbled away, by exposure to the weather, the pyrites somewhat resemble a honey-comb in shape.

The coal stands fairly well in pillars even where the seam is inclined at an angle of from 20 to 30 degrees.

It varies in hardness. The hardest coal is usually freest from impurities. That containing an excess of sulphur being very friable. Its specific gravity averages about 1·30. Various analyses show from 45 to 70 per cent. of fixed carbon; and, from 25 to 40 per cent. of volatile matter. Ash from 2 to 16 per cent.

Below will be found table of analyses :—

now employed were slaves before the late civil war. Negroes make good colliers; they can be made to obey *discipline when their personal safety is involved*, a thing almost impossible with whites,—but a great matter in a fiery colliery in America. Nevertheless of late years they have become quite as fond of strikes as white men, so collieries generally have a mixture of blacks and whites. This has been brought about by Northern men coming South, and engaging negroes by the hundred to go North where there was a strike. In most cases it was represented that the negroes were required for new collieries opening out. Generally when the strike was over the negroes were scattered, most of them finding their way back to Virginia, poorer than when they went away, and always more contented with their lot; but very liable to air their new-born knowledge of the ways of white men by going on strike. The writer well remembers what good men came from Midlothian and Clover Hill to a colliery in Ohio, with which he was connected in 1873. The pit began to make a little gas, and there were very few English colliers among its company, so it was found desirable to mix negroes with the white men for the protection of the latter, and two negroes were appointed firemen on account of their special fitness for the office.

These Virginian collieries were the penal settlements in the days of slavery. If a negro was so refractory or violent that the local whipping-master could make no impression upon him, he was sent to the pits—often with the most satisfactory results. The hire payable by colliery owners to the owners of the slave was about £30 per year, they must provide him with two suits of flannel clothes per year, must feed him well, and provide skilled medical attendance, and the slave must have a month's holiday every Christmas, and colliery owners were required to deliver back the slave under conditions, but were not responsible for his value if killed, so their

Section at Midlothian, Plate III.

The surface is from actual survey from the Greenhole Pit west. The outcrop of the main coal and the depth of pits (which are nearly in a straight line) between the Greenhole and the Sinking Pit, are taken to show the relative positions of the coal and the surface of the ground. Major Bolton, the chief engineer of the Richmond and Danville Railway, kindly supplied the elevations which enabled the writer to show the sea level.

Some years ago (since Sir C. Lyell wrote the remark that no speculator had been found bold enough to do it), a pit was started to be sunk through the clear ground into the deep basin half a mile to the dip of any other. Sinking was discontinued at 1,022 feet, because it was supposed that the coal had been passed in a "pinch," a "trouble"—whereas it would be 1000 certainly, probably 1500 feet below.

The principal pits at Midlothian lie a little distance south of the line of section. About 14 years since 3 bore holes were put down by the owner of the Midlothian. The writer saw the boring record and the cores in the colliery office in 1883, but had no opportunity of copying the former.

Mr. Oswald J. Heinrich, the gentleman who superintended the borings, has given an account of them in several papers before the American Institute of Mining Engineers. In one of the papers on the "Mesozic formation in Virginia," he gives a section from the surface to the granite and groups the rocks in a manner the writer had intended to show, but finding Mr. Heinrich's section covered 1518 feet above the granite with a coal seam near the surface, and knowing the deepest hole to be only 1137 to the granite the writer concludes that the depth of No. 2 bore hole has been placed on the top of No. 1 to make the depth for some

difficult to do away with it altogether; but some of the colliery stores in Virginia sell whisky to the serious hurt of the workmen.

The Maps Plate 1, Figs. 1 and 2 show the outlines of this coal-field and its proximity to tidal navigation, and the routes of the several railways by which the coal is carried to market. The line A across the basin, is the direction of Raccoon slope at Clover Hill, and about full dip of the measures. The line B is nearlythat of the section at Midlothian.

Plate II., Figs. 1, 2, 3, and 4 are given as illustrations of the south end of the coal-field, and are from actual survey of the writer, except those parts of the plan of underground workings shown by dotted lines on Plan, Fig. 1. These are from notes furnished by the Colliery Company's surveyor.

Neither in this nor in any other of the sections attached to this paper has any attempt been made to show the thin bands of shale (called "bones") *which divide the coal and vary in magnitude* from a mere parting to six inches thick in some places; while in others the thickest will be under an inch. These "bones" are *present everywhere*, except in some of the detached basins. The clean coal however between them is generally a respectable seam itself, sometimes four and often seven feet thick.

The faults shown on Plan, Fig. 2, as will be obvious, are not dislocations but "pinches," as though a blister had risen from an even floor when the coal matter was in a plastic state and squeezed it out. It was difficult, from the crushed condition of the sides of the main incline to determine exactly where the pinches began and ended, so the original floor of the coal, from former surveys, was taken to save the amount of cutting.

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The surface is from actual survey from the Greenhole Pit west. The outcrop of the main coal and the depth of pits (which are nearly in a straight line) between the Green hole and the Sinking Pit, are taken to show the relative positions of the coal and the surface of the ground. Major Bolton, the chief engineer of the Richmond and Danville Railway, kindly supplied the elevations which enabled the writer to show the sea level.

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›retical consideration. No. 2 was neither to the dip nor , but was drilled on the eastern outcrop of a detached n ;—subsequently proved to be so. The coal passed oubtedly represented the main coal—and the rocks led through lay between the coal and the granite, which not reached. If the position of this coal seam (5in.) hown in this section was correct, then would Sir C. ll's assertion of sterility of the rocks more than 500 feet re the coal fall to the ground.

n the borings referred to is a remarkable instance of the leading nature of the results, even with a diamond ng drill; without most constant attention to the washings n in soft ground. Two seams of coal, one 14 feet and other 12 feet, were recorded in the borings, but when the s were reached scarcely a foot of clear coal was found in whole section, and the colliery could not be worked profit.

'late IV. shows the relative positions of the celebrated ck Heath pits and the main basin. The writer took the lines of the basin from a very beautifully executed map Ashbell Welch, C.E., of New Jersey, made in 1838, arently in some connection with what is known as the glish Company. The position of the shafts are from rmation. It was Pit C that Sir Charles Lyell mentions ending.

Messrs. Jewitt's coke pit (Figs. 2 and 3) is in the main in, and from actual survey. Coke has been worked in locality only about four years. Between here and James River, about a mile from the old Bellona Arsenal, some very disturbed ground, and hematite ore was merly worked in it in a small way. The product was d for fettling.

Plate V. refers to part of the Deep Run detached coal field. e Prospect Pit particularly and the surface lines generally

are from actual survey. It is a sample of the custom of working old pits over again. A rich company from the Northern States bought up the Springfield Pits, and all the land round, including large tracts which, according to Professor W. B. Rodgers, contain no coal measures. They brought good engines, pumps, and tackling, and civil and mining engineers from Pennsylvania, built ten miles of railway, and actually began to lay out a town. Some work was done in the Oakwood Basin, but how much, the writer does not know. In the plan of the Prospect Basin, the old workings will be seen, of which the old shafts themselves ought to have been sufficient evidence. Nevertheless a shaft was sunk, and a good plant erected. A few yards from the pit bottom old workings were met with; and so little coal was found to have been left, that it was almost difficult to keep up the new workings,—shown by clear lines on the plan,—in spite of heavy timbering, good packing, and a very favourable roof. The old Scotchman, Barr (former owner), had even crept up the side of the pitch at "C" (Fig. 2 in section, (Fig. 13) and "cleaned" out the coal by stoping. When the writer went down this single unbratticed shaft, found creep lively everywhere. What little air there was the place came from old workings on the north side, and was supposed to work its way from Shaft D, though no communication had ever been made since Prospect shaft was sunk. Pits A and B were full of water, and the colliers were surprised at the quantity of water making in the north side gates. The surface of the ground, which had been strong yellow clay, had fallen in, round Pits A and B, and dropping to the bottom remained there as a tight plug 30 feet long held in position by old goaf. The new workings were separated by from 30 to 40 feet of old goaf from one of these pits.

The managing director was much concerned when he was

develop the field in accordance with sound mining knowledge—someone who has not a gambler's expectation.

It is for Virginians themselves to first prepare the way by enacting laws for the regulations of mines, without which no discipline can be maintained, and no permanent success is possible.*

On the motion of Mr. Garside, seconded by Mr. Radcliffe, the best thanks of the Society were given to Mr. Clifford for his interesting paper.

The PRESIDENT said: The paper is one which may be looked at from different points of view. In the first place, it is of historical value in the country to which it relates. Then it seems to have a value for persons who may have to compete in the coal trades, seeing that the Richmond coal-field lies only a few miles from where coal may be shipped. In the third place, it seems to have a geological value, particularly as regards the interesting points brought forward as to what has been called natural coke, and also as regards the beds of floating whin, which seem to have deprived some of the coal of its volatile properties. What has been shown here as natural coke reminds me very much of what I have seen in some of the Scotch coal-fields in Ayrshire, which in some sections was passed over as "black stone," but found since to be a very valuable heating coal. Another thing I would remark upon in regard to the Richmond coal-field is that, according to Mr. Clifford, there are only two inches between the granite and these great beds of coal. I have seen similar coal-fields in Ayrshire, and I find that the coal formation rests unconformably on the rock below; and I should rather apprehend, unless this field has been well proved, the same thing may be expected in Virginia.

Mr. CLIFFORD: That is so. The coal measures do lie in that way in Virginia.

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* See Appendix on Geology of the Richmond Coalfield, page 355.

Mr. J. RADCLIFFE mentioned that in a pit at Newtown, near Glasgow, where the Trap rock had been forced through the Coal Measures, the coal was converted into coke, and a band of ironstone rendered magnetic.

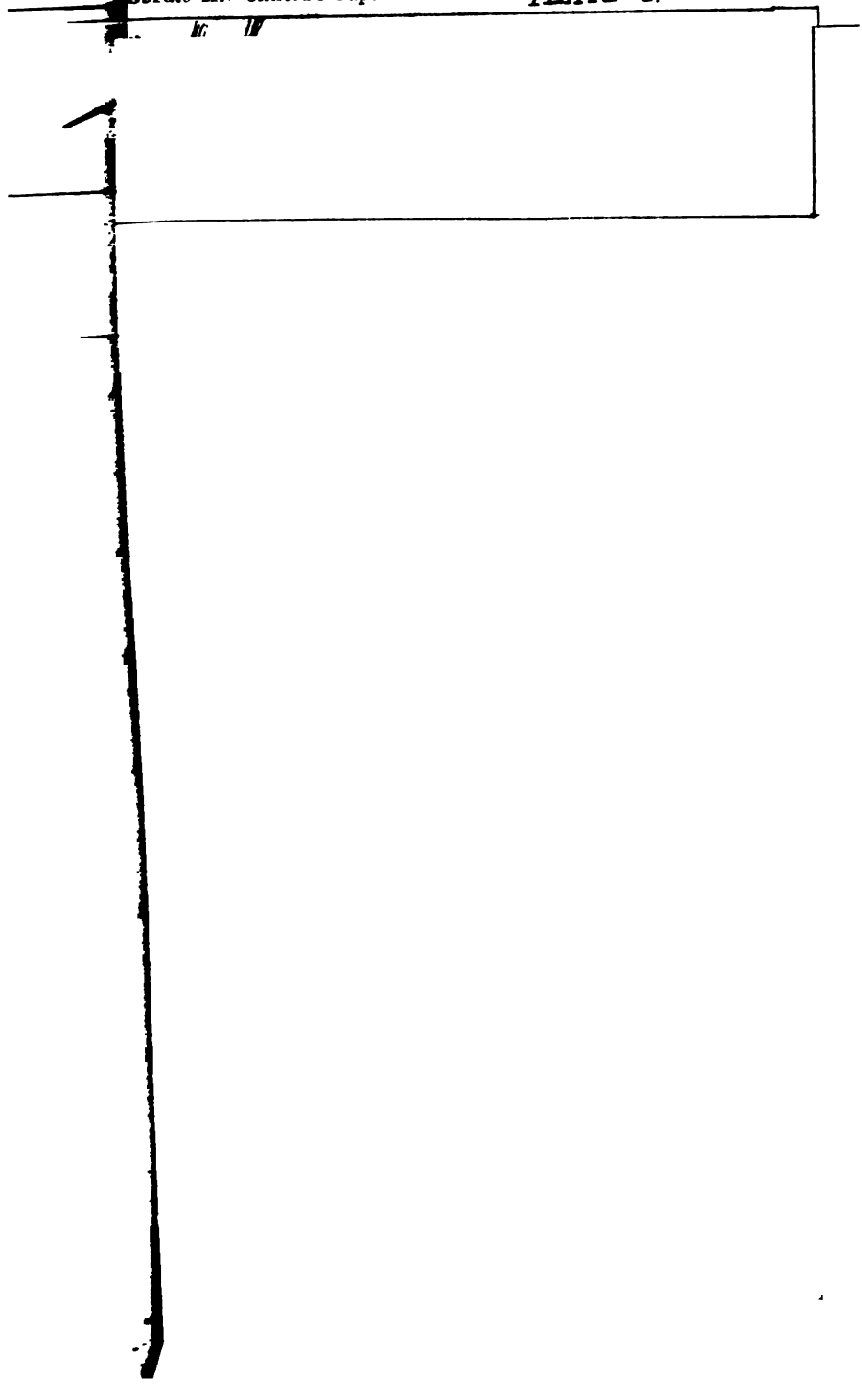
The PRESIDENT said: When I mentioned the "natural coke," or "black stone," I did not mean the cinders that are occasionally met with near some of the trap dykes, as in the county of Durham, because there you have not only the ironstone as it were made magnetic, but the coal is burnt into cinders near the dyke. The black coal produced here does not appear to be like that black cinder, nor does it resemble coke. It is what the late Mr. Binney, in describing some specimens from South Wales, called mother-of-coal.

Mr. RADCLIFFE: To the best of my belief the coke varied both in colour and density. I have a specimen where the prisms appear distinctly formed, not unlike those of the Giant's Causeway, but that was six or seven feet from the point of contact with the Trap Rock. But where there has been a great crushing, there the blackest part of the coke is, and furthest removed from the cinder-like form.

Mr. STIRRUP suggested that, in consequence of the lateness of the hour, further discussion upon the paper should be postponed, until it was printed. The paper was a valuable one, and many members might wish to have an opportunity of expressing their views upon it.

The discussion was accordingly adjourned, and the paper on "Boulders from the High Level Drift of Bacup" postponed to a future meeting.

strate Mr. Clifford's Paper. PLATE I.



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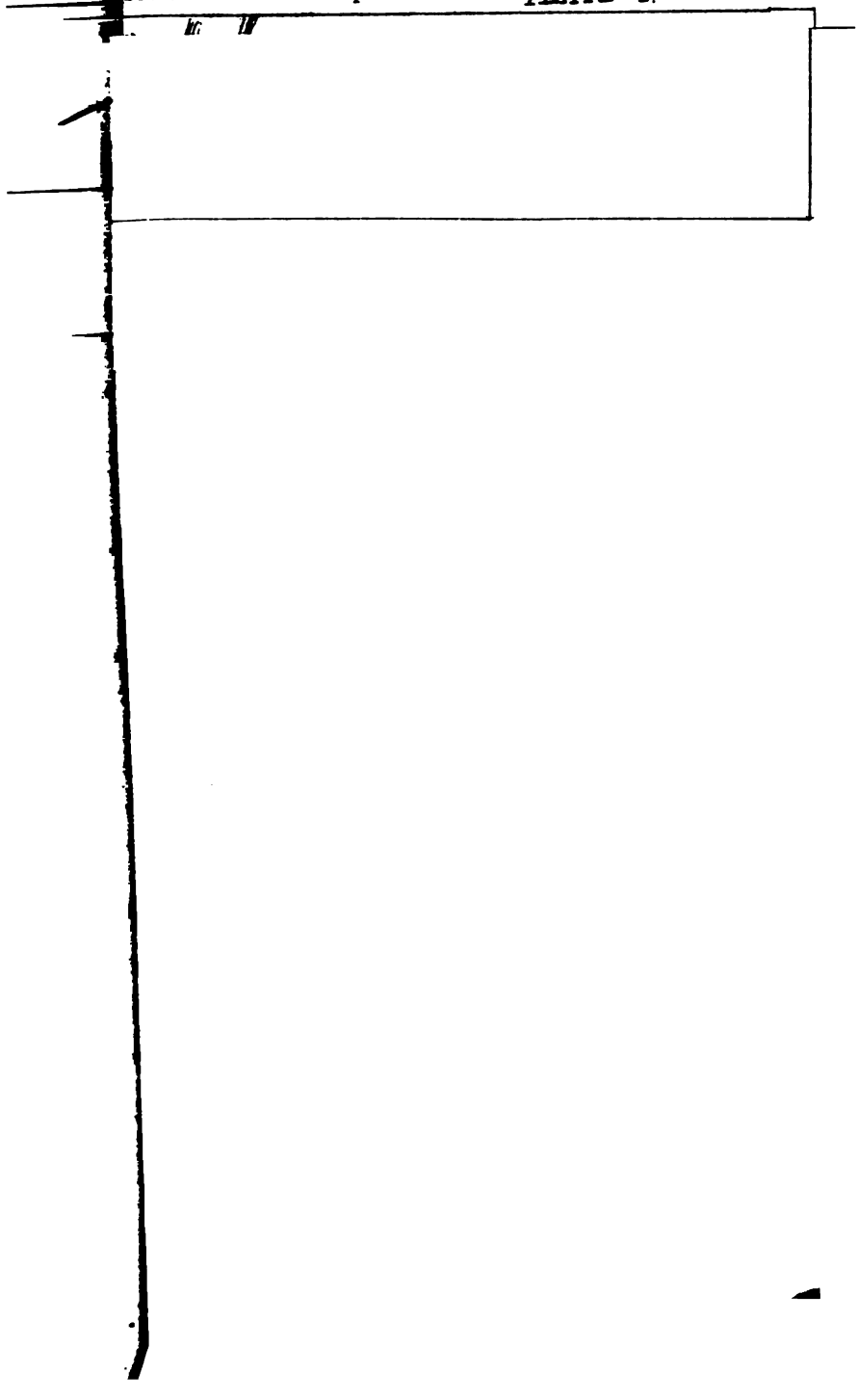

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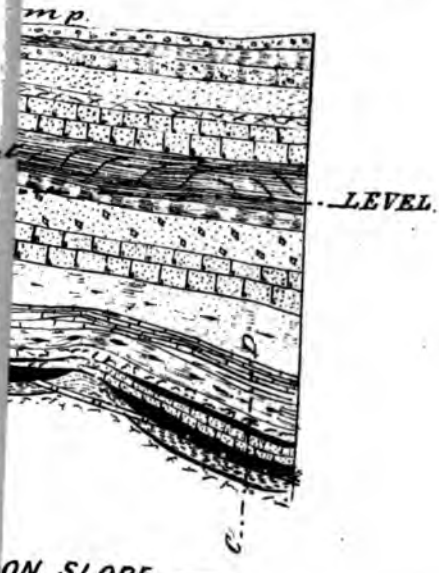
PLATE II.

FIG. 2.



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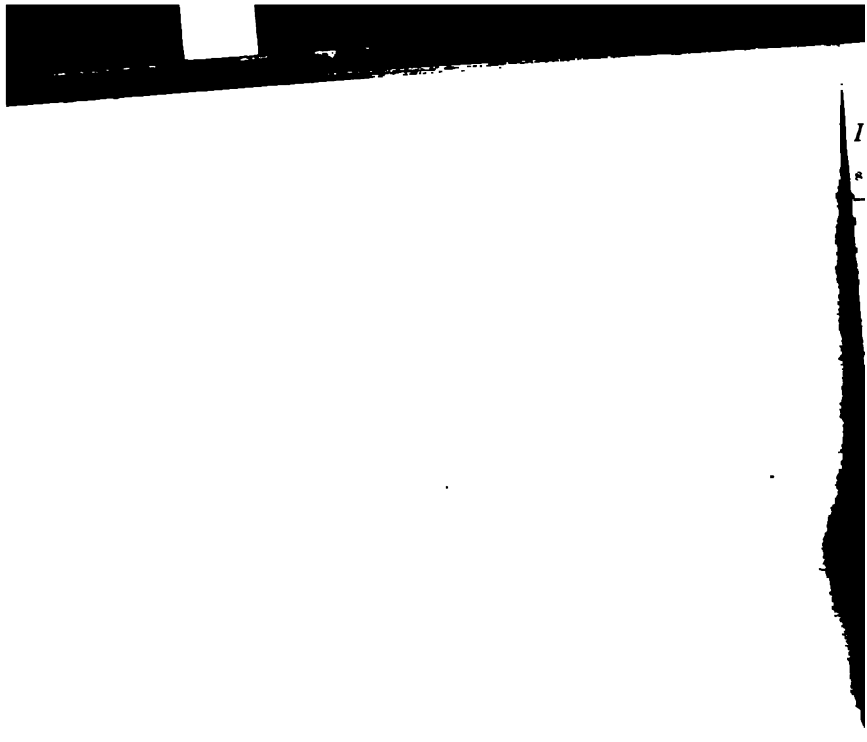

PLATE II.

FIG. 2.

ON SLOPE, ——

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IX.

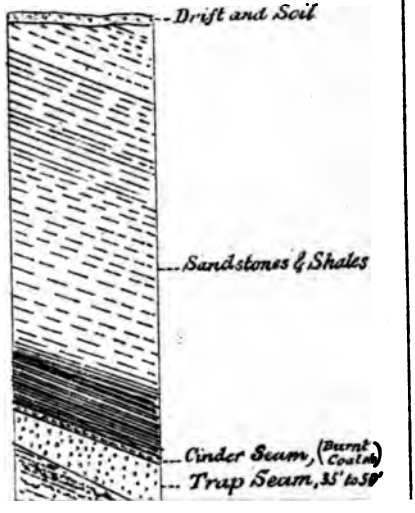
PLATE IV.

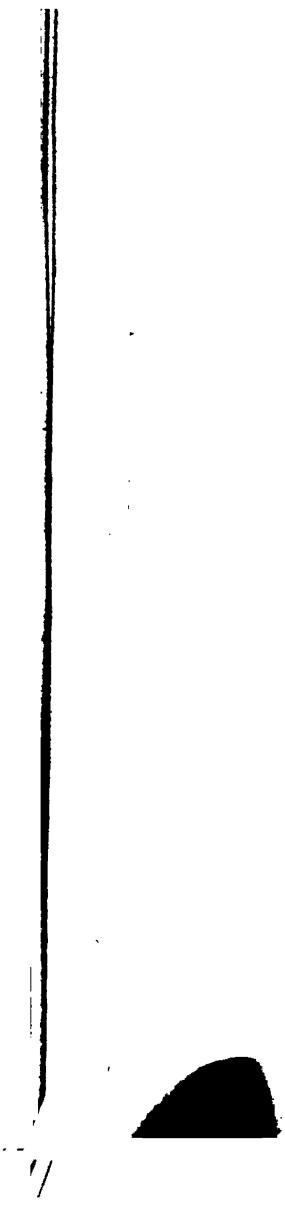
FIG. 5.

X.

PLATE IV.

G. 5.


Drift and Soil
Sandstones & Shales
Cinder Seam, (Burnt Coal)
Trap Seam, 35' to 50'



APPENDIX.

The following notes, descriptive of the geological features of the Richmond Coalfield, may be interesting to geologists. Taken from Lesley's United States Railroad and Mining Register, quoted in Macfarlane's "Coal Regions of America," pp. 509 to 514:—

Granite, Gneiss, and Mica Slate surround the Richmond Coal Field, and form its bed. Upon this face of granite was deposited a coal bed varying from 10 to 60 feet in thickness, dipping eastward from 25° to 80° on the west side of the basin, and dipping west from 20° to 40° on the east side of the basin.

The geological history of the Richmond Coal Field is easily understood. There was once a time when a mountain range of granitoid rocks rose high above the sea level, where Richmond and Petersburg now stand, and stretched away northward through Virginia, Maryland and South-Eastern Pennsylvania, as far as Trenton on the Delaware river. Towards the south it ranged past Raleigh and Fayetteville to the Dahlonega country of Georgia. A few miles further west, another and lower mountain range ran parallel to the first, but united with it before reaching the Potomac river. The valley between these two ranges of mountains was everywhere at least 1,000ft. deep, and may have been thrice that depth. Its length was at least 300 miles, and may have been 400.

We know nothing about the Atlantic Ocean coast at that time, but we know that the coal measures of Pennsylvania, West Virginia, East Tennessee, Ohio, East and West Kentucky, Illinois, Missouri, and Kansas had been deposited to their topmost layer. The Carboniferous sea had been drained, and its bed lifted up many hundreds of feet above tide level. The Eastern coal measures, with all the formations under them, in all more than 35,000ft. thick, had been bent by lateral pressure (from shrinkage of the planet or some other cause) into folds or waves, the crests of which must, in some cases, have been five miles above the level of the sea. There is nothing surprising in this, seeing that all Central Asia stands at the present day at this height, while its southern border for nearly 1,000 miles in length has even a higher elevation. The uplift of the still larger belt of the Andes is another living example of the same kind.

APPENDIX.

The following notes, descriptive of the geological features of the Richmond Coalfield, may be interesting to geologists. Taken from Lesley's United States Railroad and Mining Register, quoted in Macfarlane's "Coal Regions of America," pp. 509 to 514:—

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From the Hudson to the James the newly-formed enormous barrow shaped mountains stretched along the country, and in front of them were, by this time, the very ancient mountains of granite and schist rocks, worn down already to half or two-thirds of their original height.

Erosion goes on in all ages. From the moment the coal measures were lifted into the sky, ice and water began the long task of their destruction, which has continued ever since; until now, in the year of our Lord 1871, no point of all that vast Himalaya coal country can be found which measures over 4,000 feet above the sea. Thousands of square miles of country, once covered with 4,000 feet of coal measures, possess no longer a single ton of coal, and have even lost all the formations underneath the coal down to the limestone of the Silurian system. The coalfield once spread eastward as far as Newburg, Easton Reading, Harper's Ferry, Lynchburg, and Atlanta. Now nothing has been left between this line and the crests of the Alleghany and Cumberland mountains but in a few small patches, preserved in a few extra deep folds such as the Anthracite basins and the Broad top in Pennsylvania, and Lookout mountains in Georgia, or along cracks in the crust as at Agusta Springs, and Blacksburg, in Virginia.

But geologists no longer give sudden deluges the credit of all this destruction. The Alps are wearing away with great rapidity, before the eyes of the people of Switzerland, without the agency of any deluge. The glacier and the torrent are quite competent alone. So they must have been in times succeeding the uplift of the coal measures. But even glaciers and torrents require time for the performance of their task—immense time!

During the post-carboniferous ages, the Permian, Triassic, and Liassic formations were deposited in a hundred seas and lakes, and along the shores of all oceans around the world.

It was at this time the Connecticut river valley was filled with its brown building stone, on which are multitudes of reptile tracks; and some of the reptiles of that day were winged, like bats—Pterodactyls. At the same period, the estuary which ran through south-eastern Pennsylvania, between the South Mountain or Blue Ridge on the one hand, and the Philadelphia and Baltimore mountains on the other, was filled up with the Newark and Norristown brown building stone.

At the same time that Middle New Jersey, Eastern Pennsylvania, and the Piedmont country of Virginia and North Carolina, were

receiving their New Red deposits on a long wide estuary or arm of the sea, having its capes at Trenton and Manhattan island; the valley described at the beginning of this sketch as lying between two ranges of mountains which stood where Richmond and Raleigh are now, got filled up with over 1000, and perhaps several thousand, feet of mud and sand. These are the Richmond coal measures.

The valley had of course irregular bossy sides, like all valleys between granite mountains. On its two slopes, and in its bed, grew one of the rankest vegetations ever seen! a vegetation chiefly of mosses, and through which grew many species of ferns and shrubs long since extinct, and also an irregular forest of trees of species now extinct.

So deep was the growth of moss all over the valley, that when subsequently covered up and pressed down by a thousand or more feet of rock, and crystallized, it made a bed of bituminous coal, varying in thickness from 7 or 8 to even 60 feet.

This is the bed which the shafts at Midlothian and Clover Hill Collieries reach at various depths of from 400 to 800 feet. The coal having grown on the sides of the valley, shafts sunk near the edge of the field are shallow, while those towards the centre of the field are deep. The greatest depth of the ancient valley beneath the present surface has never been made known. But all the shafts yet sunk descend through sloping strata of Psammites, or granite-like sandstone, the washings of surrounding granite mountains into the valley, when, after the growth of the coal-beds, the continent was again sufficiently depressed below the ocean level to turn the valley into a lake or into an arm of the sea.

Had the valley been previously half-filled with water, and this lake been filled up with washings from the sides, there would have been made in time broad level meadows, and the coal bed would have been both regular in thickness and horizontal in position; or, if the movements of the earth disturbed its horizontality, the dip or strike of the bed would have obeyed some regular law which geologists might discover and miners conform to. But the fact seems to be that the coal bed was formed almost immediately after the valley itself was excavated, and therefore upon a very irregular surface, and in very unequal thicknesses—filling, as it were, ravines and basins in the sides and bottom of the ancient valley, which has made mining an embarrassing business.

The geological difficulty will not, however, stand in the way of the proper development of the Richmond coal basin, when those into whose hands its property tracts fall, learn that before a shaft is sunk the whole of the ground of any proposed colliery must be carefully studied with the diamond drill.

We have often turned with a sort of wonder to regard the Richmond Coal basin. Its history is very strange. It was one of the earliest opened by the miner. It is the solitary one at tide-water and near a state capital, for Rhode Island coal basin does not deserve the name. It contains several beds of coal, and one of these sometimes of the great thickness of 60 feet. It is mined on the English plan, and affords a variety of fuel from gas coal to natural coke. One would have expected its complete development long ere this.

A little reflection, however, will serve to explain the phenomenon. *The Richmond Coal Field is in Virginia; and Virginia has been in a profound sleep for a hundred years, a sleep undisturbed by dreams of any other than a political complexion.*

Industry was always ignoble in Virginia; speculating in money making was always under a sort of ban. Investments in unwieldy breadth of soil was the only vogue. The manufacturing element of society was carefully excluded from the commonwealth. Wood was always in plenty for the hearth and the forge; and why raise stone coal, where there were neither steam mills, cotton mills, nor woollen mills, coke stacks nor puddling furnaces in the region? The Tredegar Iron Works could supply itself from Baltimore, or raise enough from a single shaft with 50 black miners to supply all its needs. From the Blue Ridge to the sea shore, and from the Potomac to the Savannah, no one thought of using stone coal for any purpose whatsoever. If they had the capacity, the Richmond field would have been developed; for it stands alone, or stood alone, the solitary source of mineral fuel for a region 500 miles long and 250 miles wide. The Deep River basin was almost, and the Dan River basin was wholly, unknown. Even now the latter remains practically untouched, and the former is not to be compared with the Richmond field for situation and size of its beds.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XIX. SESSION 1887-8.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, 6th January, 1888, in the Mining School, Wigan.

Mr. W. S. BARRETT, Member of the Council, in the Chair.

Mr. W. WOOD, who had promised to exhibit and describe a Miner's Safety Lamp, with his patented improvement for extinguishing the flame in the vicinity of explosive gases, said that—owing to illness—he was not ready with his lamp, but he promised to bring it before a future meeting.

Mr. G. H. HOLLINGWORTH (one of the Honorary Secretaries) said that Mr. Emmerson Bainbridge, of the Nunnery Collieries, Sheffield, had forwarded the following paper, and had written to say that he had sent his lamp on, but it had not yet arrived at the Mining School:—

ON A NEW DESCRIPTION OF MINERS' SAFETY LAMP.

By Mr. Emerson Bainbridge, M.Inst.C.E.

During the past few years a large number of safety lamps have been brought before the mining public, and whilst the primary object of the inventor has generally been to enable the lamp to stand a high velocity of explosive current, the other objects aimed at have generally been as follows :—

1. Good illuminating power.
2. Self-extinguishing lamps to extinguish when opened.
3. Mechanical "shuts off" to be applied by the miner.
4. Self-acting "shuts off" in which the gas in the lamp automatically causes the closing of the orifice through which the lamp is fed with the fresh air.

The new Mines Act, which came into force on the 1st of January, during the present year, contains several new regulations with regard to safety lamps, the most important of these being that a safety lamp used underground shall be of such description as will not fire an explosive current impinging against the lamp at a velocity, the same as that which exists in the place where the lamp will be in use. Thus the Davy, Stevenson, and Clanny lamps are practically condemned.

The lamp designed by the author, and submitted to your Society to-day, has the following special features :—

1. It is a lamp composed of only four movable parts, which parts are simple, and easily put together, instead of there being about ten parts, as is the case with some of the modern improved safety lamps.

2. The lamp bottom, being subject to great wear and tear, is made specially strong where *most needed*. The

inside of the brass bottom is covered with tin, which, whilst preventing corrosion, maintains the full lighting power of the illuminant used.

3. It is suggested that, on the ground of economy and superior light, deodorised spirit (which costs one-half as much as oil) should be used, the flame being adjusted by means of a ring round the wick tube, and an ordinary thumb screw or pricker. Although spirit is recommended, colza, seal, or other oils may be used if preferred.

4. The glass is about $\frac{3}{4}$-inch longer than the ordinary Clanny lamp glass, and is made of a specially clear and transparent quality of glass, polished at both ends, and properly annealed. It can be cleaned in its place, and need never be moved except in case of accident. As special provision for expansion by heat is made, breakages will necessarily be few.

5. The glass frame, or body of the lamp, is supported by four pillars, which are so placed as to allow $\frac{3}{8}$ths or more of the glass to be free from a pillar, and its consequent and objectionable shadow.

6. The gauze can only be taken out by removing the locked bonnet. This is done by having the top of the lamp to unscrew. The top is locked by a bolt, which is also fastened by the lock securing the lamp.

7. The holes at the top of the bonnet are made above the gauze, and the cap of the gauze is of metal instead of the usual gauze, thus insuring a much decreased wear and tear.

8. This lamp has been tested in the highest explosive current, at a velocity of *over 30 feet per second*, and does not explode, *but is found perfectly safe.* It should be noted that this velocity is *twice as great as is met with in any ordinary coal mine.*

9. All parts of the lamp are interchangeable.

10. The proportions of the glass and gauze, and the position and size of the inlet and outlet holes for air are special, and have been decided on after a series of careful experiments.

11.—Safety, economy in burning, cleaning and repairing, bright illuminating power and lightness (consistent with strength) have been specially aimed at in designing this lamp.

It will be observed from the characteristics which have been referred to, the novel points in the lamp are as follow :—

1. The air being admitted at the side of the bonnet dispenses with the use of holes through the brass frame, the strength of which is thus not interfered with.

2. The screw by which the bonnet is attached to the main part of the lamp is a male screw, the ordinary attachment being by a female screw. The advantage in favour of the former is that the inlet of air to feed the flame is brought nearer to the flame itself.

3. The inner shield has the effect of acting as a barrier against a current of explosive mixture, and increasing the safety of the lamp in such mixture.

4. The severe repairs which lamps require are largely due to the illtreatment they frequently receive in being screwed and unscrewed, and especially in screwing up the glass. In the lamp submitted this evil is dispensed with, as the glass when once placed need not be removed until it breaks.

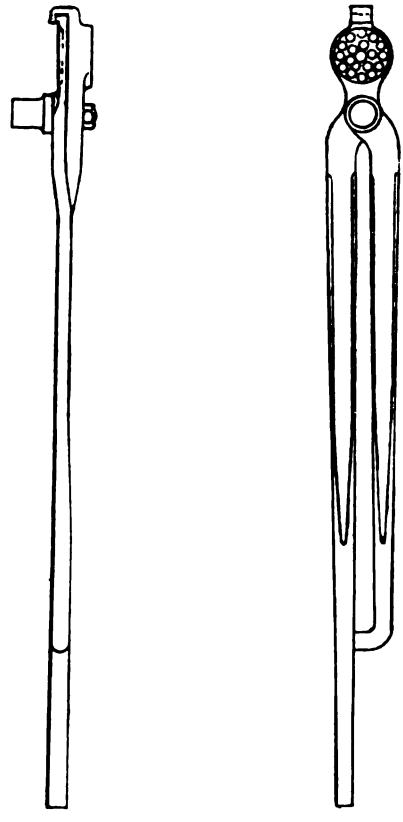
5. By increasing the distance apart of two of the pillars supporting the glass frame, the usual shadow caused by the centre pillar is dispensed with. The writer does not know

to what extent the upper part of the lamp could be applied to existing Clanny lamps, but believes there will be no difficulty in making a bonnet to suit existing lamps at a small cost. Through particulars which have been taken out at a number of collieries, the author finds that where oil is used the cost per year for lamp cleaning, including everything, amounts to 15s. or 16s. per lamp, and with ordinary deodorised spirit the cost is about 10s. per year. By the use of spirit in a more economical way, by storing the spirit in proper chambers to prevent evaporation, and by an improved mode of burning the spirit, the writer expects to be able to use the lamp described at a cost of not more than 7s. 6d. per lamp per year. Another arrangement of the lamp provides for a "shut off," and this is shown on the other drawing accompanying the paper, but the author has found that a "shut off," which acts excellently in a still atmosphere, frequently fails to act in a strong current of air as the very smallest leakage will cause enough air to pass to support combustion; in fact a shut off is much more an ingenious adjustment to a lamp than a practical advantage. The lamp has been tested at a velocity of the highest explosive current at 30 feet per second, and has been found quite safe, and as the first cost is low, the author hopes that its special features, and the economy in lighting, cleaning, and repairs; its simple construction and safety in working, will cause the lamp described to be interesting to your Society.

The CHAIRMAN said it would be very difficult to discuss the merits of the lamp in the absence of the lamp itself and therefore the discussion had better be adjourned.

A NEW LEAD RIVET MOULD.

By Mr. Henry Bramall, M.Inst.C.E.



In the absence of the inventor, Mr. Henry Bramall, of Pendlebury, Mr. George H. Hollingworth (one of the Honorary Secretaries), exhibited the machine, and read the following description of this new patent tool for making lead rivets for locking safety lamps. He said: Of the various methods of securely locking safety lamps, perhaps there is none better for adaptability,

efficiency, and general handiness than the simple lead rivet. But care should be taken to have the holes in the lamps rymered accurately to the same shape and size, and the rivets should fit tolerably well, be of sufficent length and solid. The rivet moulds heretofore in use are apt to turn out "blown" and imperfect rivets, and require a second operation after the moulding to detach them from the "head" and "gits." To overcome these defects the patent mould now exhibited has been devised. It consists of two parts joined by a centre pin, somewhat like a pair of pincers, the jaws sliding in contact like a pair of shears. The lower jaw has on its upper side a series of 20 holes of the form of the rivet it is desired to make, and which constitute the moulds; and the upper jaw is dished on its upper side, and a series of holes or gits are bored through to correspond with the moulds in the lower jaw when closed. There is a wedged shaped piece on the upper jaw which slides into a sort of slot piece on the lower jaw and locks them firmly together when closed. The handles are long and strong to afford ample leverage, and one of them is bent so as to form a stop when the jaws are closed in proper position. The method of using is extremely simple. The mould is closed and melted lead carefully poured in, and as soon as this has set, the handles are separated, the jaws being fitted very close, shear off the gits, and on the mould being turned over and dropped on the projecting pin the rivets are shaken out, finished ready for use; the gits and heads also fall out and are easily picked up and returned to the melting pot. With one of these moulds one man (aided by a boy to melt the lead) can easily make 30lbs. per hour or 2,700 rivets. With two moulds about 45,000 rivets per day can be turned out. These moulds are in daily use at Messrs. A. Knowles and Sons' Collieries, and have proved very satisfactory.

Mr. BURROWS said there seemed to be no provision for knocking the rivets out of the holes.

The CHAIRMAN: They drop out.

Mr. BURROWS: That is the theory. We have a machine for knocking them out, but sometimes they stick if there is the least roughness. That is the only weak point I see in it.

The CHAIRMAN: Would not a bit of grease obviate that?

Mr. BURROWS: It would go on for a few months and then occur again.

Mr. E. BRAMALL: You have only just to reverse the machine.

Mr. TEALE said they had a machine in operation at their works which turned out 250 to 300 a minute. It was self-feeding, drew the wire the exact length, and cut it off It seemed to him that their machine did the work much more efficiently and at a cost of only 1s. 7d. per thousand.

Mr. E. BRAMALL: The great advantage of our machine and using rivets is that you can use the old ones up again, and also utilize any old scrap lead.

AUTOMATIC LOCK FOR SHIELDS OR BONNETS OF SAFETY LAMPS.

Mr. TEALE introduced a new patent locking arrangement by Mr. James Radcliffe, of the Dukinfield Collieries, which has for its object the securing of the shield or bonnet to miners' lamps when at work. The improvements in lamps had gone on to such an extent that we were, observed Mr. Teale, in the difficult position of having lamps so securely shielded that they did not admit of proper inspection and might be allowed to go down into the mine in a dangerous condition. Some of the shields in use at the present time

were fastened to the upper part of the lamp, completely covering the gauzes inside, and making it impossible for the examiner to efficiently examine the lamp before it was taken into the workings, as required by the New Mines Regulation Act of 1887. This difficulty in not being able to see at a glance the whole of the lamp had sometimes led to the lamp being sent down the mine in an imperfect condition. Instances had occurred where the lamp had been sent down without any gauzes in, and in other cases, where the gauzes had not been taken out for cleaning purposes, holes had been found made by the brush of the lamp-cleaner, and which could not be seen if the bonnet were fast on the lamp. Mr. Radcliffe's invention admitted the use of a loose shield or bonnet, which could only be taken off when the lamp was pulled to pieces. It was the last part to be taken off and the last part to be added when preparing the lamp for its work. The upper part of the shield carried a snug, which, when the shield was put over the lamp top, dropped through a recess cut in the cover of the lamp, and which, on pushing the shield round a little, passed over a spring fitted on the underside of the cap or cover of the lamp. Immediately this snug had passed the spring it came in contact with the standard of the lamp, and it could then go no further, whilst the spring prevented its getting back, and the shield or bonnet was automatically locked. To unlock or take off the shield the whole of the lamp had to be taken to pieces and a pressure applied to the underside of the spring. The shield could then be slid back until the snug on the shield was opposite the recess, when the bonnet could be taken off. The lock could be fitted to different parts of the lamp, but by preference it was fitted to the underside of the cover, and it could be applied to any lamp on which the shield was used. In taking it from the lamp-room to the examiner the shield was put on the lamp but not locked. It could then be lifted off

by the examiner, who could see the whole of the lamp at once, and then be put on and locked by simply turning the shield round on to the spring. The arrangement was neither costly nor complicated, but simple and efficient, and not liable to get out of order.

Mr. BURROWS said the only loose shield he had previously seen required a second lock. The one which had been shown and described seemed to be very simple, and needed no second lock, as it locked itself.

AN IMPROVED TIN CAN LAMP.

Mr. HENRY HALL, Government Inspector of Mines, observed that a strict interpretation of the new Mines Act might possibly prohibit any lamp being used in a mine where the glass or the shield was movable at the discretion of the person using the lamp, except for the purpose of firing shots. He had designed a lamp specially to meet this requirement, and he submitted it to the meeting. It was a new arrangement of the tin can type of lamp, but differed in several important particulars from the general character of this class of lamp. In his lamp he got the air from the top part, so as to be readily able to detect gas. Also, when it was opened for the purpose of lighting shots the light was not exposed. The lamp consisted simply of three pieces—a shield, gauze and oil receiver. The shield, as already intimated, had perforations at the top, instead of the bottom, as in the general run of tin shields, and the gauze was made slightly narrower than in the ordinary Davy lamp gauze.

Mr. MAWSON: Does that lamp give off as much light as one with a bigger gauze?

Mr. HALL: I do not think the size of the gauze makes any difference. A narrow gauze has this advantage, that it does not pass flame in a current so readily as one of larger diameter.

The CHAIRMAN: Is not the gauze nearer the flame than in most other lamps?

Mr. HALL: Yes, the gauze is nearer, so as to keep it away from the glass.

Mr. WINSTANLEY: Does it not get heated?

Mr. HALL: No. I am certain that having the holes at the top is a great improvement, both in searching for gas and in keeping the top of the lamp cool. The lamp has those two advantages.

A NEW ELECTRIC MINER'S LAMP.

Mr. OSWALD SWETE, representing the Sun Portable Electric Lamp Company, exhibited a portable electric miner's lamp, which excited considerable interest. This lamp, he explained, was the invention and patent of Mr. David Urquhart, C.E., and when charged and in working order, weighed only 3½lb.; it was 9in. in height, exclusive of the hook to carry it by, 3⅝in. in diameter, and the elements were contained in a solid tinned teak box of ¼in. thickness and perfectly watertight. This was divided into two cells, and all connections were of platinum or metal platinised, so that the dilute sulphuric acid used in the battery had no corroding action upon them, and the points of contact were thus kept clean and bright. The cells were fitted with a lid rendered watertight, which was kept closely down upon them by a metal cover and union screw similar to a hose coupling. Upon this coupling was a brass wire cage protecting a toughened glass cylindrical dome, inside of which

by the examiner, who could see the whole of the lamp at once, and then be put on and locked by simply turning the shield round on to the spring. The arrangement was neither costly nor complicated, but simple and efficient, and not liable to get out of order.

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was a small incandescent lamp, fitted in a spring holder. Underneath, and pressing upon the toughened glass dome, was a strong spring, so that should the dome be broken accidentally—which was only a very remote possibility—the incandescent lamp would be forced to the top of the wire cage, thus breaking instantaneously all connection with the battery, because when toughened glass was cracked in ever so slight a degree, the whole fell to powder and thus left no large pieces to intercept the lamp from breaking connection with the battery. The electro-motive force of this battery was 4·7 volts and the current 0·5 of an ampére for twelve hours with a charging from a dynamo machine of three or four hours. The battery was not a secondary battery, as many inferred, neither was it a true primary battery, but a kind of primo-secondary giving a much higher electro force than either a primary or secondary. The batteries could be easily re-charged by a dynamo machine, a so-called one-unit machine being capable of charging about 150 of these lamps, taking about 1½ horse-power to effect this. The lamp would burn in any position, upside down if required, and the light could be switched off if necessary. Another form of the lamp was one in which there was a hooded reflector behind the incandescent lamp, throwing a strong beam of light in front of the lamp. The light emitted was exactly four times that of a Mueseler mining lamp. The lamp had been tested at Rotherham in a testing chamber and had failed to fire an explosive mixture every time it had been tested, even when both dome and incandescent lamp were broken. The cost of maintenance, including charging, repairs, &c., and renewals of elements, came to 3d. per lamp per week.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XIX. SESSION 1887-8.

EVENING MEETING AT THE OWENS COLLEGE.

A SPECIAL MEETING of the members was held in the NEW MUSEUM BUILDINGS, Owens College, on the Evening of Friday, 27th January, 1888, at the invitation of the Principal and Council of the College.

The members, after partaking of tea and coffee (kindly provided by the College authorities), assembled in one of the new lecture halls to hear a paper on the "Old Red Sandstone Fossil Fishes from the Caithness Beds," by Mr. G. Edward. The President, Mr. Joseph Dickinson, F.G.S., occupied the chair, and was supported by the Principal of the College, Professor W. C. Williamson, F.R.S.; Professor W. Boyd Dawkins, F.R.S.; and Mr. E. Douner.

The PRESIDENT said: There are two subjects for this evening which may occupy some time—first there is Mr. Edward's paper on the fossil fishes of the Old Red Sandstone; and after that we are to hear Professor Williamson describe some of the beautiful fossils which are now to be

seen in the Geological room. I will, therefore, not occupy the time of the meeting by offering any remarks. I would, however, like to say one thing. As one of the oldest members of the Geological Society—one who was very much attached to the old museum in Peter Street, and who regretted to see the collections removed so far from the centre of the city—I think, seeing the admirable arrangements made here for the housing of those collections, that we cannot but come to the conclusion that a great change has been made for the better. We have now a museum which, although it is not yet fully arranged, will be worthy of the city to which it belongs. Perhaps Professor Dawkins will say a few words on the present state of the museum and the probable time when it will be complete.

Professor Boyd Dawkins said: Mr. President, and gentlemen: I feel a double pleasure in seeing the Manchester Geological Society here this evening. First, as a member of the Society who has been doing his best for some years to advance the study of his special subject in this part of the world; and, secondly, from the fact of my having had the custody of these magnificent collections for so many years, and of having at last seen within my reach the realisation of a dream. You know that these large collections are very largely due to the pains and the trouble and the care which have been bestowed upon them by, for the most part, members of the Manchester Geological Society, and you cannot but be aware that for the last 15 or 16 years, by the force of circumstances, it was quite impossible for these collections to be made accessible and useable. Well, gentlemen, when you see this evening what there is in one part of the museum, at all events, you will see that the authorities of the college have done their very best to give a due and fitting home to this collection; and I, speaking from the purely college side of the question,

would say that all of us will do our very best to make this museum, as a whole, worthy of Manchester. With regard to that part of it which more intimately concerns the Geological Society—the geological part—I think that I am not too bold when I say that I look forward in about, say another year's time, to Manchester possessing a museum which will be, perhaps, alone in some respects among the museums in this country, owing to our having taken advantage of our unique position with regard to the coal measures. From what you have seen to night, you will gather an idea of what we are doing; and I hope that when in the future you come here, when you come again to visit these collections which were made originally by you, and which were handed over to the college for the good of the public, you will be able to see in these collections no mere dead lot of fossils without any human interest, but you will see that they tell a story of the ancient history of the earth so plainly and simply—so free from long words —that even a child may learn something from them.

THE OLD RED SANDSTONE OF CAITHNESS AND ITS FOSSILS.

By Mr. G. Edward.

A glance at a geological map shows that the Old Red Sandstone rocks of Europe have by far their largest development in the British Isles, and that the greatest deposit is in Caithness—which is the most northerly county in Scotland. Hugh Miller, the great high priest of the Old Red Sandstone system, who was to the Old Red what Sir Roderick Murchison was to the Silurian, thought that the most of Scotland had at one time been covered with Old Red Sandstone, and he imagined that all over Scotland he could find proofs of his theory.

Time has brought changes, and it is now generally believed that the Old Red Sandstone was formed in separate lakes or inland seas, and Professor Geikie, who is an authority on the subject says:—"The Old Red" of this country was deposited in five detached basins. The most southerly he calls "*The Welsh Lake*," extending from Shropshire into South Wales.

The largest and most northerly he calls "*Lake Orcadie*," it lies in the north side of the highlands of Scotland, skirts the slopes of the mountains along the Moray Firth and the east of Ross and Sutherland, stretches through Caithness and the Orkney Islands, and at one time, he says, may have continued to Norway and Russia."

"The Old Red Sandstone of the northern basin, says Geikie, is typically developed in Caithness, where it consists chiefly of the well-known dark bituminous and calcareous flagstones of commerce. It rests unconformably on schists, granites, &c. Zones of red and conglomerate sandstones graduate upwards into the flagstones. The total depth of the series in Caithness, he estimates at upwards of 16,000 feet."

Such is Professor Geikie's description of the Old Red Sandstone deposit in Caithness.

For over thirty years I have been more or less in touch with the fossil beds of what Professor Geikie calls "*The Lake Orcadie Old Red Sandstone deposit.*" I got my first lesson at the fossil fish beds of Gamerie.

Hugh Miller was visiting friends of his in Aberdeenshire, that occupied the next farm to my father's, and being at home on holiday, and hearing that Hugh Miller was going to the fossils at Gamerie, I became a hammer-in-hand companion, and shall never forget the thrill that went through me when I laid open my first fossil fish.

Since then I have spent many a happy day hammering among the northern fossil beds; but for years Caithness has been my favourite hunting ground, and the fossils before you to-night are trophies from that field.

My first day among the Caithness fossils is as fresh in my memory as if it had been yesterday. Business took me north, and having read Hugh Miller's graphic description of the Caithness fossil beds, I was looking forward to a feast among the fossil fishes.

Travelling northward by rail I was struck with the great contrast between the scenery of Caithness and the neighbouring county of Sutherland. The scenery in Sutherland is bold, and the hills are steep, wild, and rugged. Caithness is bare, barren, flat, and treeless. Although the inland country of Caithness is flat and uninteresting, the sea coast is the reverse. Great wild precipitous cliffs rise hundreds of feet above the sea and, where faults occur in the strata, the waves of the ocean have scooped out black, deep gorges and wild weird-like caves through which the sea hisses, thunders, and moans like the wail of unjust spirits.

Holborn Head was my destination, and the tools I had brought with me consisted of a small pocket hammer, a

heavy single handed hammer, some chisels, and an old spade.

Some of you may laugh at the old spade, but if you go among the Old Red fossils at Caithness you will soon find out the value of an old spade. After half-an-hour's walk I left the highway and, following a footpath along the green flowery braes, came to what is known as the "*Deils Brig*," which is a great rent in the sandstone rock, over which there is a natural bridge.

Standing on the bridge and peering down you can see the green depths below, and hear the boom of the waves in the subterranean caves. One of these caves is said to be three miles long, and during storms the spray may be seen ascending from an opening far inland—like the smoke from a factory chimney.

The small slab marked (Co) with plant-like dendritic markings is from the "*Deils Brig*." An hour's walk along the braes and over the cliffs brought me to what is known as "*The Cleft*," which is a great detached mass of grey flagstone that rises perpendicular out of the sea, but within gun shot of the land. Myriads of sea-birds hover round and sit on the ledges of the rock, which is inaccessible to man.

Near "*The Cleft*" I commenced tirring and breaking up the shales, and soon found a pretty complete fish, but as the rocks were very rotten and the scales of the fish rather indistinct I gave it up, and, shouldering the tools, marched on. Arriving at Holborn Head I found the cliffs a hundred-and fifty to two hundred feet high, and although the day had been bright and warm, the wind off the Atlantic was bitterly cold. After half-an-hour's prospecting I commenced operations close on the edge of the cliffs on a light grey thin laminated schist, and was soon rewarded by finding fossil fish by the dozen. By inserting chisels at different points,

and using the old spade as a lever, I could lift slabs several feet square.

Between the laminations there was a kind of sweaty dampness and, after exposure to the atmosphere, this damp seemed to affect the stone and the fishes, which were fairly clear and bright when first exposed, but soon became dim and indistinct. After quarrying and hammering for some time I gave up the find, as the fishes were not worth carrying home. Within a radius of half-a-mile I found a great variety of fossil beds. As a rule, the fossils are best preserved in the thicker and harder schists; but, of course, the thinner and softer beds are easiest got at.

Quarrying fossils on the bare rocks at Holborn Head is no child's play, and I soon found that enthusiastic geologising had to be paid for in blistered and bleeding hands.

All alone, with no human being or habitation in sight, I sat in solitude on the bleak barren rock.

No sound broke the silence save the wail of the sea-bird and the moan of the ocean. There I sat thinking, thinking of the myriads of ages that had passed since the conglomerate of the Old Red Sandstone had its pebbles rounded in a wild, tempestous sea; thinking on the time when the rocks on which I sat were the soft muddy bottom of a primeval lake, and the fishes I had been disinterring had gamboled in its waters; thinking of the immense time it must have taken to build up this deposit, layer upon layer, until it became what it is; thinking of the mysteries of life and death of the generation after generation of these curiously-formed fishes that were part of that creation of which we ourselves are a part, and that had lived, and died, and were buried in these rocks.

Little more need be said about my first day among the Caithness fossils, except that every day has not yielded the same results.

The discoveries made by Hugh Miller and others reveal the fact that no section of the earth's crust is more clearly marked with a distinct individuality.

Its fossils are so unlike, what went before and what came after, that we may say of the Old Red that it is a distinct creation, and these fossils prove that it was a creation of a higher type of animals and plants than what went before, and so it has been from the earliest dawn of plant and animal life till now.

The march has been an unbroken, progressive, onward and upward march.

These fossil plants are the harbingers of the great carboniferous flora, and the fishes are the beginning of that vertebrate life that culminated in man.

A cordial vote of thanks having been passed to Mr. Edward for his paper, Mr. H. M. Ormerod moved, and Mr. Mark Stirrup seconded a vote of thanks to Principal Greenwood and the Council of Owens College, for the hospitable reception they had extended to the members, and for the privilege of meeting in the New Museum.

Principal GREENWOOD, in responding, said: Mr. President and gentlemen: In the name of the Council of Owens College I thank you very sincerely indeed for the cordial way in which you have accepted the resolution moved by my friend Mr. Ormerod, and seconded by my old pupil and friend Mr. Stirrup. I can assure you that the Council is never more sensible that it is performing the duty—I may say the gratifying task—which belongs to it than when it is furnishing societies like this with the means of holding their periodical meetings. We have, I trust, no narrow notion of the functions that belong to us as an academic body. It is quite true teaching is our primary object, but we are well aware that all academic bodies that are at all

For a long time I was puzzled to know how some specimens were so perfect in some parts and other parts very imperfect or missing altogether. The explanation was that the Old Red fishes were part osseous and part cartilaginous, and the osseous part was preserved and the cartilaginous part decayed. The same as when a shark rots, all its cartilaginous framework decays, and nothing remains but its enamelled teeth.

(*Mr. Edward here described some of the representative fishes, such as the Pterichthys, Coccosteus, Cephalaspis, Osteolepis, Holoptychius, Glyptolepis, and others, of which fine specimens were exhibited.*)

I have often wondered why the Old Red fishes were clad in strong coats of mail as the bulk of them are. As yet I have been unable to get a satisfactory reply to the question, but the limit of research has not yet been reached, and someday those who in imperfect light are groping for evidence may be able to solve the mystery.

Those of you who are collectors know how interesting some of your specimens become to you. They are almost like old friends, and their features are as familiar.

Nearly every separate fossil in this collection has a story of its own to me. A story that no one but myself could tell. I mean the story of where I got it, how I got it, and all its surroundings. Mine was the first human eye that ever looked on many of them. You will not wonder, then, when I tell you that my great difficulty to-night has been, not want of something to say, but how to squeeze what I had to say into the time at my disposal.

In the presence of these fossils we can hardly realize that not many years ago writers on geology treated the Old Red formation as if it were of little interest, being, as they said, non-fossiliferous.

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equal to their ideal do something more than that—that, to gather around them learned societies to promote research, not on the part of young men only, but of men advancing in life, is almost as important a part of their work as that of directly teaching those who are in the stage of pupildom. We therefore feel that we are answering this true ideal of the college when we furnish societies like yours with facilities for carrying out their task. I further would say that we are under a great debt to the Manchester Geological Society and the late Natural History Society for making us the custodians of the large and valuable collections which now form the Manchester Museum. It is not only that you have done us a great service in placing these collections within our walls, but Professor Williamson and Professor Dawkins will agree with me when I say that we are grateful to you for the real stimulus which you applied to our scientific faculties by making to us these splendid gifts. (Hear, hear.)

ON THE FOSSIL TREES OF THE COAL MEASURES.

By Professor W. C. Williamson, F.R.S.

The meeting then adjourned to the Geological Museum, where some fine examples were to be seen of the large forest trees of the Carboniferous period, which have been recently set up. Attention was called to the great Stigmarian root, which Professor Williamson said was unique in its grandeur. He had no hesitation in saying that it was the largest fossil in any museum in the world.

Professor Williamson, addressing the members who were assembled round this noble specimen, said:—Eighty or ninety years ago geologists were familiar with little fragments of fossils that they found in the sandstone and other beds of the coal measures which went under various names.

In 1828 M. Brongniart, the great French botanist, gave to these specimens the name of Stigmaria, from the numerous stigmata that I have just referred to; but the question was, what were these Stigmariæ? About the year 1830 some specimens were found—nothing approaching to this which is now before you—but showing what constituted the material features of this plant, namely, a number of radiating arms spreading from a dome-shaped centre. If you turn to the first volume of the Fossil Flora of Great Britain, conducted by Hutton and Lindley, you will discover a diagram representing their idea of this fossil. They thought that it was a huge floating plant, with numerous branches radiating from a central dome, but as to what this plant was they were all at sea. It was only when the Bolton railway was constructed by Sir John Hawkshaw, that the two trees of which you have casts on the other side of the room were found. At that time my two oldest friends, the late Mr. Binney and the late Mr. John Eddowes Bowman, came to the conclusion that these Stigmariæ were nothing more nor less than the roots of a gigantic tree. They hit, in this, upon the truth. At a very early period of my own investigations I thoroughly made up my mind that Mr. Bowman and Mr. Binney were right—that this was a root—not only so, but that they were right very much beyond what either of them anticipated. We have in our coal measures certain stems which are called Lepidodendra—that is the stems of a gigantic race of plants allied to the club-mosses, known to every botanist. Now Mr. Binney and Mr. Bowman said that the Stigmariæ were the roots of the Sigillaria, but neither of them knew that they were also the roots of the Lepidodendron. Mr. Binney, shrewd as he was, assigned a very different object to represent the root of the Lepidodendron from what we now know to be the case. We now know that Sigillaria and Lepidodendron are both alike

tion at Liverpool the idea was scouted by all the botanists present—namely, that these Carboniferous cryptogamic plants grew by exogenous development, layer after layer thickening their stems, exactly as an oak or an elm tree grows. Was there anything so outrageous as for a man knowing anything of botany, to state that these great cryptogams grew exogenously? My old friend Brongniart—the highest authority, then living, on these things—had ventured to say that if there was exogenous growth in a stem, that stem could not possibly be that of a cryptogam. It was not known that any living cryptogam had such a growth; therefore they did not believe that any fossil one could have it. Now what is the truth? It turns out that there is scarcely a plant of any kind that lived at the time of the coal measures which had not this exogenous growth. Nearly all grew exogenously in those days. The great trees that grow exogenously now, the oaks and the elms, did not exist. I did for a long time think that there was an exception in the case of the ferns; but within the last few months I have got some magnificent stems which show—and my friend, the Count de Solms, has arrived at the same conclusion—that certain plants in which we have got exogenous growth are ferns; and if that be so we have to admit that nearly all the plants which grew in the Carboniferous age grew exogenously. This, then, gentlemen, is to be received as the explanation of the absence of rootlets from these thick roots. They have grown exogenously, and, as they did so, the superficial part of the bark, with its attached rootlets has been cast off. I have in my microscopical cabinet one of these roots with its little rootlets given off all round it, and each rootlet, with its wood and bark included, is only three-sixteenths of an inch in diameter. This is another of those things that has had to be taught to some of our French friends. They believed that all these roots

terminated in a thick boss, like a pumpkin; they could not be got to believe that these things were merely ordinary roots, thick near the stem, but that they tapered away like all other roots; but here we have a true Stigmarian root less than a quarter of an inch in diameter furnished, as I have said, with its own rootlets. Now the question naturally arises—how does this large specimen happen to have been preserved so splendidly? As to this I think there can be no doubt whatever. The probability is that these trees grew in swampy ground, just as the swamp cypress grows in America at the present day. I say that because, though we find associated with them in the coal measures stems like the stems of pines, we never find, or very rarely find them in the same layer of rock in which we find these Stigmarian plants. We generally find them separated, under conditions which show that the Gymnosperms had grown higher upon the mountains, and in drier situations. What happened then? This tree was certainly 100 feet high at the very least. The stem, after the tree ceased to live, decayed downwards until the decay reached the point which you see here; but that point being high and dry above water, the decay did not go any further. Why? I presume because it was covered over by mud, and thus protected from the action of the air; and the woody structure of the root remained longer and better protected than any where else. Well, the next step was this; though decay could be resisted for a time it could not be resisted for ever. Little by little, for anything I know hundreds, and even thousands of years may have elapsed after the stem disappeared before the woody tissue of the root decayed; but ultimately it became decayed carbonaceous matter. In the meantime the bed of earth in which this tree grew had become hardened; layers of sand had overlain the shaly matter in which the roots were embedded, and ultimately the sand covered the whole

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XIX. SESSION 1887-8.

The ORDINARY MEETING of the Members was held on Tuesday, February 7th, 1888, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOSEPH DICKINSON, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society, viz.:—

WILLIAM WOOD, Engineer, 6, Broome Avenue, Levenshulme.

GEORGE EDWARD SCARBOROUGH, Colliery Manager, New Town and Meadows Collieries, Wigan.

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Essex Naturalist: No. 12.—*From Essex Field Club.*

found in a quarry in the very middle of one of those thick sandstone beds which were found in the Lower Coal Measures, or Gannister series of Lancashire and Yorkshire, with which many of the gentlemen present were familiar, the sandstone being apparently identical with the Upholland flagstones.

In reference to further questions Professor WILLIAMSON said:—The study of these plants has entered on a new phase. We now find that a very important investigation has to be carried out, namely,—the study of the different plants that are characteristic of different horizons in the coal measures, and we want all the aid that gentlemen engaged in the coal mining can possibly give us, by collecting every fragment of a fossil that can be found, and carefully noting from which layer of coal it was obtained. We ask you to be good enough to bring or send them here. Let them, by all means, be accurately labelled, as regards the actual coal from which they came. We have now to study the change that took place between the deposition of the rocks of the mountain limestone, of Derbyshire and elsewhere, and the deposition of the coal of the Worsley mines. With this task before us no fragment need be considered too insignificant to send us. We are extremely anxious—and Professor Dawkins has the same feeling as myself—to ascertain carefully and accurately what the fossils are that characterise each of the layers of coal, in all parts of the world; and in any work that you undertake, to help us in that investigation, you will be affording a very important aid to the study of the Coal Measure flora. (Hear, hear.)

This concluded the business of the meeting.

NOTE.—The monograph on Stigmaria ficoides, published by the lecturer in the Palæontographical Society's Volume for 1886, contains an elaborate history of both the internal organisation and external relations of these roots, as well as a photograph of the subject of the lecture before its removal from the Clayton quarry.

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Essex Naturalist: No. 12.—*From Essex Field Club.*

London—Royal Society: Proceedings, Nos. 259-260, Vol. XLIII.—*From the Society.*

——— Royal Institution of Great Britain: Proceedings, Part 1, Vol. XII.—*From the Institution.*

——— The Geological Record: 1879.—*Purchased.*

——— Palæontographical Society: Vol. XLI., for 1887.—*Purchased.*

——— Institute of Mechanical Engineers: Proceedings, Nos. 3 and 4, 1887. Library Catalogue, Subject Index of Papers, 1847-87.—*From the Institute.*

——— Iron and Steel Institute: Journal, No. 2, 1887.—*From the Institute.*

——— Geological Magazine: Nos. 1 and 2, Vol. V.—*Purchased.*

Midland Institute of Mining Engineers: Transactions, Part 92, Vol. XI.—*From the Institute.*

Mining Institute of Scotland: Transactions, Parts 6-7, Vol. IX.—*From the Institute.*

Newcastle-upon-Tyne—North of England Institute of Mining Engineers: Part 1, Vol. XXXVII.—*From the Institute.*

North Staffordshire Naturalists' Field Club: Annual Report and Transactions, 1887.—*From the Club.*

Royal Institution of Cornwall: Journal, Part 2, Vol. IX.—*From the Institution.*

Salford Royal Museum, Libraries, &c.: Annual Report.

Canada—The Canadian Mining Review: No. 10, Vol. V.

U.S.A., Cambridge—Harvard College, Museum of Comparative Zoology: Curator's Report, 1886-7.—*From A. Agassiz.*

——— Philadelphia—Franklin Institute: Journal, No. 744, Vol. CXXIV.; No. 745, Vol. CXXV.—*From the Institute.*

——— Shenandoah—The Colliery Engineer: Nos. 4-5, Vol. VIII.

Australia—Royal Society of New South Wales: Journal and Proceedings, Vol. XX., 1886.—*From the Society.*

——— Department of Mines, New South Wales: Annual Report, 1886.—*From the Government.*

——— Department of Mining Geological Survey: 1887. Geology of Vegetable Creek Tin Mining Field.

Victoria—Annual Report of Secretary for Mines and Water Supply.

——— Gold Fields of Victoria: Report, 30th September, 1887.

——— Mineral Statistics of Victoria, 1886.

——— Natural History of Victoria: Prodromus of the Zoology: Decades, 1-15.—*From Fred McCoy, F.R.S., Director of Victoria Museum, Melbourne.*

New Zealand—Reports of Mining Industries, 1887.

Buenos Ayres—Report of Commerce, Argentine Republic: No. 55, 1887.—*From the Government.*

Halle a/s—Vereins für Erdkunde, 1887.—*From the Society.*

Paris—Revue de la Legislation des Mines, September-October, November-December, 1887.—*Purchased.*

Pisa—Atti della Società Toscana di Scienze Naturali: Vol. VI.—*From the Society.*

Rome—Atti della Reale Accademia dei Lincei: Fasc. 6, 7, 8, Vol. III.—*From the Academy.*

St. Petersburg—Mémoires du Comité Géologique: Nos. 4-5, Vol. II.; No. 3, Vol. III. Bulletin: Nos. 8, 9, 10, Vol. VI.; Supplement: Vol. VI.—*From the Institute of Mines.*

——— Académie Impériale des Sciences: Mémoires, Nos. 2-7, Tome XXXV.; Bulletin, No. 4, Tome XXXI.—*From the Academy.*

Natural History of New York: Palæontology, by Jas. Hall: Vols. I.-V., in seven Vols., Text and Plates.—*Purchased.*

Organisation of the Fossil Plants of the Coal Measures: Part XIV., by W. C. Williamson.—*Presented by the Author.*

The following books were presented by W. Whittaker, F.G.S.:—

Mémoires de la Société Géologique du Nord: No. 3, Vol. I., 1882.

Sanitary Institute of Great Britain: Address to Section III., 1886.

Chester Society of Natural Science: Fifth Annual Report, 1875-6.

Miners' Association of Cornwall: Report and Proceedings, 1871, 1872-3, and 1874-5.

Geological Survey of Alabama: Report for 1879-80.

Annual Report Californian State Mineralogist, 1884.

Mr. STIRRUP, Hon. Secretary, reported that he had received a circular from the Geological Society of Australasia with reference to a conference of Australian Geologists, to be held in Melbourne during the opening of the Centennial International Exhibition in the month of September of the present year, asking for the co-operation of English Geologists and the contribution of papers on various subjects, a list of which is given in the circular. He would be glad to forward the names of any members of the Society willing to contribute such papers.

Mr. Stirrup also mentioned the fact that the fourth meeting of the International Geological Congress was to be held in London in the month of September. The Congress originated in 1876, at the Buffalo Meeting of the American Association for the Advancement of Science. Three meetings have since been held—in Paris 1878, in Bologna 1881, and in Berlin 1885. A very influential committee had been formed for promoting the success of the London meeting, most of the Presidents of Societies like the Manchester Geological Society had become members, and the coming meeting, it was anticipated. would be the largest ever held. Several subjects of geological interest would be brought forward. The principal idea with which the movement started was to assimilate the colouring of geological maps, and also to secure uniformity in geological nomenclature all over the world. There was a map of Europe, now in course of construction, upon the principles advocated, the colouring and the names being universally accepted by geologists. Of course other matters of geological importance would be discussed, but probably the main feature of the Congress would be the opportunity afforded of personal communication with many distinguished foreign geologists. The subscription was 10s., and subscribers were entitled to the whole of the publications, which were issued during the meeting and the final Report, which were well worth the money.

The PRESIDENT: If any members wish to join the Congress for this year they will perhaps give their names to the Honorary Secretaries. I have put my name down.

The PRESIDENT stated that he had received some papers from Mr. Bunning, the Secretary of the North of England Institute of Mining Engineers, from which it appeared that an effort was being made to establish a federation of all Societies in the kingdom which had objects in connection

with mining. He (the President), however, thought this was a matter which was not urgent, and might fairly stand over. The Manchester Geological Society exchanged its transactions with all the leading Societies in the country, including the North of England Institute.

The Honorary Secretary (Mr. STIRRUP) read the following paper in the absence of the author :—

OBSERVATIONS ON BOULDERS FROM THE HIGH-LEVEL DRIFT OF BACUP.

BY MR. HERBERT BOLTON.

In July of this year my attention was drawn to the opening of a pit in a bed of drift sand at Slack, a mile east of Bacup.

During the process of excavation I obtained the rock specimens now laid before you.

A hasty glance is sufficient to show that the greater number are of volcanic origin, whilst detailed examination will, I think, show them to be derived rocks from the English Lake District.

By means of Walker's Steel-Yard Balance I have determined the specific gravity of most of the specimens, in the hope that it may prove of service in fixing upon the exact locality from which they have been derived.

Specimen A has a sp. gr. of 1·55. It is a very coarse granite, with (in addition to the essential constituents) magnetite and a large amount of iron oxides. The felspar is easily decomposed, and in most boulders of this class kaolinisation has been very active. These boulders are tolerably abundant. Careful comparison would seem to show that this specimen is identical in character with a type

specimen of Eskdale granite, now in the Jermyn Street Museum.

Specimen B has a sp. gr. of 1·604, being slightly heavier than the one just mentioned. It presents much the appearance of syenite, but I believe it to be a granite. It consists of quartz in small crystals, mica (muscovite?) and orthoclase felspar. A large crystal of the latter exhibits twinning. Magnetite is, I think, present, and the rock contains a large amount of iron oxides. This specimen closely resembles Skiddaw granite.

Specimen C has a sp. gr. of 2·51. It is possibly a trachytic lava. It is a close textured rock of a green colour, and shows a laminated arrangement of the particles on a freshly broken surface. Very small plates of mica are plentifully diffused through it.

Specimen D. The sp. gr. of this I have not determined. It is a dark green rock, much similar to the last, but crystals of some kind are very evident and abundant. It has the rough feel peculiar to trachytes, and I class it with the last specimen as a trachytic lava.

Specimen E is a beautifully banded rhyolite of a yellow or ochre colour. It contains, like all rhyolites, a great number of air cavities, so much so, that when immersed in water, the noise of the escaping air is quite audible. The banded structure is very evident.

Specimen F has a sp. gr. of 1·57. It is most probably a horn-felstone or Halleflinta, and has a dull horny-looking surface. It is traversed by several veins of quartz, which are in all likelihood intrusive and not the result of segregation. On a freshly broken surface it shows an irregular banding, which cuts the quartz veins at an acute angle. Fracture is very irregular. It closely resembles the Halleflinta of Coniston.

Specimen G has a sp. gr. of 2·5. Possibly a quartz

trachyte or quartz rhyolite. The matrix is of a reddish-yellow or brick colour, and contains large crystals of dull looking quartz.

The matrix is very soft, yielding readily under the knife.

A black mineral is present in some abundance, but its precise nature I have been unable to determine. It is interesting to note that most of the quartz crystals have a well-defined hexagonal outline.

A somewhat similar rock to this occurs at Birkbeck Fells in the Lake District.

Specimen H has a sp. gr. of 1·64, and is apparently a felsitic lava. It is of a dark colour, and where subject to weathering shows well-marked planes of foliation. Eroding agents would seem to act along planes of some particular mineral, for the planes of foliation are rendered more distinct as a result of weathering. This rock is one of the most plentiful, and at a later stage I shall have to refer to it again.

Specimen I has a sp. gr. of 1·75. This is a dark compact felstone, of a micro-crystalline structure. It weathers yellowish green. A freshly broken surface reveals what appear to be planes of jointing, coated over with a brown deposit.

Specimen J has a sp. gr. of 1·64. Probably a felstone. It presents a mottled appearance on a freshly broken surface, varying in colour from dark green to brown. It weathers white with broad patches of brown, due to iron oxide, and streaky masses of a green chloritic-looking alteration product are produced. Boulders of this character are very common.

Specimen K has a sp. gr. of 1·668. This specimen consists of a micro-crystalline base, in which are scattered quartz crystals, and crystals of a reddish brown colour. Flat crystals of a rounded outline, and capable of being

scratched with a knife, are also present. The reddish crystals I suppose to be felspar, and the loose material a felsitic one. What the rock is, I cannot tell, unless it be a felspar porphyry.

Specimen L has a sp. gr. of 2·38. Probably a felsite. It varies in colour from yellow to a faint pink, and is apparently micro-crystalline.

Specimen M has a sp. gr. of 1·643. This is a small rounded fragment presenting a peculiar mottled appearance owing to being made up of irregular masses of different mineral matter. It appears to be composed of angular fragments in a micro-crystalline base, and I should suppose it to be of eruptive origin. Careful examination shows that the included matter is mostly lenticular in shape, so that the rock presents the appearance of fluxion lines. Larger boulders of this rock show the darker mineral matter standing out in the form of rounded bosses above the general surface contour.

Specimen O has a sp. gr. of 1·53. Probably a quartz felsite. It is a hard compact rock of pinkish hue, and traversed by two small veins of quartz. Quartz crystals are also scattered through the mass.

Specimen P has a sp. gr. of 1·66. It is a micro-crystalline rock, of a deep red colour. The outer surface is marked with numerous striations, running in various directions.

It is a very hard and durable rock.

Specimen R is a rock consisting of an irregular mixture of green quartz and a brown mineral. What it is I am unable to conjecture, though it would in all probability be easy to refer it to its parent rock owing to its characteristic appearance.

Specimen S has a sp. gr. of 1·554. This specimen is of a resinous brown colour, passing into olive green on the most weathered faces. The weathered faces are much pitted,

and it is semi-transparent on thin edges. It breaks with a sub-conchoidal fracture, and is either a fragment of flint or chalcedony, though of unusually low specific gravity.

Specimen U has a sp. gr. of 1·8. This is, perhaps, the most important of all the specimens, since it contains a fossil in beautiful preservation. The rock itself is a black chert, splitting with a smooth face, and having a dull waxy lustre. It is perfectly opaque on the thinnest edges, and altogether distinct from the previous specimen.

The fossil is probably *Orthis striatula* (?) a form characteristic of the Llandeilo Beds of the Lower Silurian.

Specimen V has a sp. gr. of 1·45. It is a fine-grained red sandstone, foreign to the district. An oxide of iron serves as the cementing material. Flakes of mica are abundantly scattered through it.

Specimen W has a sp. gr. of 2·03. It is a sedimentary rock, foreign to the district. It is a fine-grained sandstone, full of minute plates of mica, and cemented together with an iron oxide. The original bedding planes are quite evident.

Specimen Y is a sedimentary rock, possibly of local origin. It is a fragment of brown shale, and has much the appearance of dried mud.

In addition to these specimens, fragments of rocks of local origin are abundant; many of them are rounded or of an oval form, and distinctly striated. I obtained from the pit a sandstone boulder of about 5 inches in diameter, which shows these striations very well.

The pit also yielded a fragment of calliard rock in the form of a stigmarian cast, whilst small particles of shale were abundant.

The sand itself is of an angular nature, and the pit had been dug to a depth of about 8 feet without reaching a bottom. The upper surface of the bed is in contact with the soil, which is very shallow, being about 3 inches in depth.

So far as I was enabled to make out, the sand had stretched over several acres, and is locally known as the Sandfield.

It is interesting to note that beds of similar character are found at two places within a distance of 2½ miles from Sandfield, viz.: at the Bacup Cemetery and at Stacksteads.

The altitude of the three places is, however, different. Slack is about 1150 feet, Bacup Cemetery about 1000 feet, and Stacksteads about 950 feet above sea level. These beds of drift sand were undoubtedly deposited at the same time, and in my opinion were originally continuous, and had a much greater area than at present.

I am led to these conclusions by the following facts:—

The elevation at which the beds of drift sand occur would seem to indicate a former slope stretching from east to west, and having a length of 2½ miles. The extreme point of this slope on the east I take to be the flank of Hogshead Moor at Causeway House at an elevation of 1150 feet; and Heath Hill, Stacksteads, on the west, at an elevation of 900 feet.

Secondly, the sand in either case is finely angular, and when moist is very coherent. This would seem to indicate that the sand is of the same nature.

The third reason, and the most conclusive one is that both on the flanks of Hogshead Moor, Brandwood Moor and the low range of hills bounding the Stacksteads valley on the north, there is present a bed of Boulder clay, which runs up to a height of not less than 1300 feet in several places.

At Slack I have found this bed of Boulder clay overlapping with its lower margin the bed of drift sand in the same meadow from which the specimens were obtained, and traced it up the hill to a height of over 1200 feet.

The late Capt. Aitken traced the same bed over the summit of Brandwood Moor at an elevation of 1250 feet,

and also found traces of it at Bull Hill, Haslingden, at an elevation of 1371 feet. At Mow Grain, west of the Broadclough Valley, I have picked up fragments of volcanic ash (similar to what is found in the boulder clay), at a height of 1250 feet.*

A fragment of felstone has also been found at Derplay Hill at an elevation of 1370 feet. During the past summer I also came upon patches of the same bed upon Heald Moor, which has a height of 1370 feet to 1419 feet, and is in line with Derplay Hill. I attribute the breaking up of the once (presumably) continuous beds of drift sand to those causes which operated in the deposition of the boulder clay at these high elevations. The boulder clay is variously coloured, being in most places highly charged with oxide of iron, which stains it a deep red or yellow. Boulders occur in profusion, and are much similar to those now before you, only of larger size, the majority being about a foot in diameter, and striated.

At an elevation of 800 feet, and forming the floor of the lower part of the Burnley Road and Stackstead Valleys, and also underlying the town of Bacup, is a bed of stiff blue clay, containing very few boulders, and having a thickness of about 100 feet.

This bed is, I believe, the oldest as well as the lowest of the drift deposits of Rossendale.

In conclusion, I may say that the result of my observations would seem to indicate the presence of three well-defined beds of Glacial Drift in the Bacup area; the first being a stiff blue clay of great thickness; the second, a bed

* In a narrow ravine, known as "Peter's Clough," and at an elevation of about 950 feet, occurs a drift boulder similar to Specimen H, and having the following dimensions:—Major axis, 31 inches; minor axis, 27 inches; thickness, 24 inches. The planes of foliation ran along the major axis, and I have been unable to make out any evidence of striation. The boulder has been brought from a higher point by the stream flowing through the clough, and it is even now washed by the water in its passage downward.

which is to some extent represented on that map. If Mr. Carvill Lewis had been in this room (and I hope we may have the pleasure of seeing him here soon) it would be satisfactory to fight out our points of difference. With regard to that map which has been handed round, I should like to say that it does not represent the facts of English boulder geology with accuracy. It is an exceedingly imperfect map, and it does not give the distribution of the boulder clays in—Essex, for instance. It ignores the fact that such deposits as these are to be found not only on the Western side of the Pennine Chain, but also on the Eastern slopes. According to Mr. Carvill Lewis's view the ice, which has done such a tremendous amount of work, started in some mysterious way, contrary to the laws of gravitation, at the bottom of the Irish Sea, and worked its way up-hill till it reached the top of the Pennine Chain, and there stopped. That, I need hardly say, is contrary to all experience. Ice always moves from higher to the lower ground, though it is perfectly true if there is a considerable head of ice it will override minor elevations. Then, with regard to these boulders, to the evidence itself. These boulders, brought by ice, are to be found everywhere in the Pennine Chain—equally on the East as on the West side. They exist on the other side of the Pennine Axis, in the neighbourhood of Todmorden, and also on the hills above Sheffield, at altitudes ranging to 1,000 feet and more. Therefore, I do not quite understand how the said glacier of the Irish Sea can be supposed to have stopped at the top of the Pennine Chain. It must have gone right over; and, further, when we get these same stones scattered as far as the line of the Humber, it seems to me there is practically not much use in that map. Mr. Carvill Lewis's view is that a great mass of ice filled up the whole

very likely to have been one of the deposits spoken of by Mr. Bolton. Mr. Carvill Lewis has had a wide experience of glacial phenomena in North America, and also in various parts of the European Continent, and has spent many months of holidays in Ireland, and in various parts of England, in trying to gather some definite data in support of a theory he maintains, which he thinks holds good all over the northern hemisphere. I have here a sketch map which he exhibited at the recent British Association meeting in our city, of the glaciation of England, in which he shows that the ice field came down on the eastern side of England, blocking up the estuary of the River Humber, and filling the bed of the North Sea; the same phenomena are depicted on the west side of England and Scotland; the Irish Sea being choked up with a glacier. There is a red line drawn across the map where he shows his terminal moraine. The Irish Sea glacier is seen protruding on to the land in Lancashire as far as the Pennine Chain; and he says:—"In the neighbourhood of Manchester the great moraine of this Irish Sea glacier may be followed through Bacup, Hey, Stalybridge, Stockport, and Macclesfield, being as finely developed as the moraines of Switzerland and America. South of Manchester it contains flints and shell-fragments, brought by the glacier from the sea bottom over which it passed. At Manchester the ice was at least 1400 feet thick, being as thick as the Rhone glacier." I am not sure that all Mr. Carvill Lewis has said with regard to these terminal moraines will be able to be borne out; and so far as I understand his theory, I think that it is a little in advance of, if not at variance with, the facts, so far as Lancashire is concerned.

Professor Boyd Dawkins said: Mr. President, I certainly feel relieved to hear Mr. Stirrup conclude his remarks by not taking up the point of view that Mr. Carvill Lewis advanced at the meeting of the British Association, and

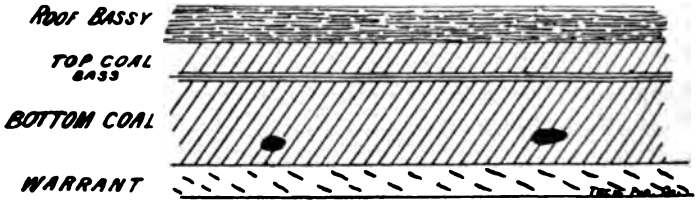
when Professor Lewis said that it was to be seen at Bacup. Where in the neighbourhood of Bacup it is to be seen I, for one, do not know. It would be rather interesting to discover.

The following communication by Mr. HENRY COWBURN, of Leigh, near Manchester, was read in the writer's absence by one of the Honorary Secretaries (Mr. M. STIRRUP):—

ON BOULDERS IN COAL SEAMS.

"I send you herewith two boulders which I found a few weeks ago, in the Five Feet mine at Brookside Colliery, Leigh. This mine is called the "Six Feet" or "Nine Feet" at Wigan and the Trencherbone at Worsley.

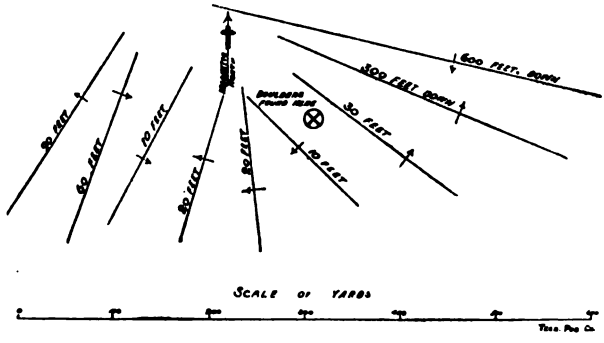
They were firmly fixed in the growing coal about six inches from the bottom of the seam, as under:



They are both more or less water worn, and appear to be formed of a very hard fine sandstone. I have never before come across any myself, but a collier tells me that a few months ago he found at least twenty of them lying in a space about 3 yards by 2 yards (all were rounded), and the colliers words were: 'that the place where they were found looked like an old brook bottom,' but he did not think it worth his while to bring any of them out of the pit. The two I send you are not at all like any of the surrounding

strata, in fact the only sandstone we have is quite 20 yards higher, and immediately below the Four Feet mine.

"You will see from sketch below that the ground is very much broken up with faults."



ON FOREIGN BOULDERS IN COAL SEAMS.

By Mr. Mark Stirrup, F.G.S.

The Coal Measure Rocks of Lancashire, as elsewhere, consist for the most part of a series of siliceous sandstones of various grain and texture and thick beds of shale, among which are distributed the coal seams, with their associated under-clays or seat-rocks.

Now in these coal seams, of purely vegetable origin, and in the roof close upon the coal, are occasionally found pebbles and boulders of rocks differing totally in aspect and composition from any of the rocks which occur in the carboniferous system.

They are in fact erratics, just as much as the boulders in the Glacial Drift; wanderers probably from some old mountain land, whence they have been carried by storm or flood, or may be they are voyagers from some ancient sea board, upon whose unknown shore they were rolled and

worn, in ages long prior to the oldest rocks of the carboniferous formation.

The difficulty that at once presents itself with regard to these boulders, is, what cause can we assign for their presence in their actual position seeing that the characters and structure of the beds of coal and the shales which entomb them, indicate agencies, for their accumulation, which have been slow and tranquil in their operation, while, on the other hand, these intrusive strangers suggest, by their presence, the action of sudden and transient forces; the problem therefore for solution is, whence did they come and by what means were they transported?

The importance that attaches to these boulders is, that could we read their history aright and ascertain whence they came, it would give us some clue to the physical features of the old land areas in pre-carboniferous times, and enable the palæo-physiographer to construct his charts with a greater probability of correctness than at present.

Further, could the means by which these boulders were deposited in the coal be clearly pointed out, they would either confirm or refute the arguments of those physicists who contend that this earth of ours has experienced great periodic alternations of climate, cycles of cold and heat, due to cosmic causes, acting through all time.

The presence of these foreign boulders in coal seams has been long known, but they have always been considered rare and phenomenal.

The late Mr. E. W. Binney, in 1851, read a paper on the subject before the Manchester Literary and Philosophical Society (*vide* Vol. 9, 2nd. series, p. 306), in which he describes and figures some rounded grey quartzone stones from the 4-feet mine at Patricroft, and from another seam under the same mine at Pendleton. These stones varied in weight from 2¾lbs. to 6½lbs. Mr. Binney says, "their composition

is the same, though found in different seams and at different places." And again, "Each of the seams in which the boulders occurred (and they were found in the middle of the beds) is placed on a floor full of stigmaria roots, thus affording conclusive proof that the plants of which the seams were formed grew upon the spots where now found."

Other notices may be found in the Transactions of the Manchester Geological Society by Mr. Plant, the late Mr. Aitken, and other members.

Mr. Plant, in 1874, reports their occurrence in the Two Feet Trencherbone Mine at Kearsley. He says:—"These boulders are reported by the miners to be of rare occurrence in the coal beds, but when they do occur, it is in groups of five, six, a dozen, or even twenty, all lying in a limited space, but separately embedded in the coal."

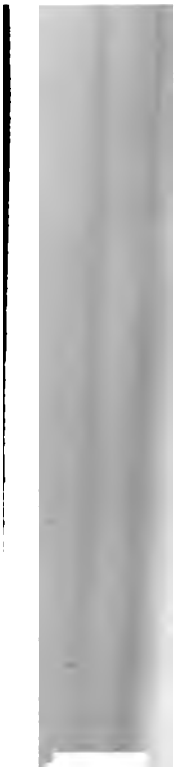
These boulders are, as a rule, hard siliceous grits or quartzites, ranging in colour from pale to dark gray, and would betoken by their character and mineralogical composition that they were all derived from one common source.

The description of a few of our Lancashire boulders, now exhibited, will apply to those of many other districts, so uniform are they in appearance.

Though differing often in form and size, they have this common characteristic, that they are smoothed, often polished, with the corners rounded off by abrasion.

Their forms are various; roughly quadrangular, irregularly ovoid or elliptical, occasionally globular, and all have been evidently water-worn, before being deposited in the coal strata, as is shown by their rounded contours.

A thin film of coal or shale, according to the matrix, is often found closely and firmly adherent to the surface, and this coating has not unfrequently the appearance of the polished surface known as "slickensides," which has pro-



mine, which is worked at a depth from the surface of 300 to 350 yards.

These pebbles where they touch the coal are often coated with iron pyrites, and exhibit, fixed on the carbonaceous skin which surrounds them, teeth, scales, and spines of fishes.

Mr. James Radcliffe, of the Astley Pit, Dukinfield, in working the Roger Coal of that district, has found numerous boulders, some of very large size, which he has recently described before the London Geological Society (Q. Jour. Geo. Soc., Vol. 43, p. 599), some specimens of which he has kindly sent here for exhibition.

They are all gray grits or quartzites, which differ little in appearance, and probably are all from one source.

Small ones of 5 to 6 lbs. are not uncommon, but he has obtained two large ones from the same seam, weighing respectively 100 and 156 lbs.

They occur at a depth from the surface of 500 to 550 yards, and are found lying near the top of the Roger Coal and usually half imbedded in it, as shown in the block of coal exhibited.

The Roger seam is upwards of 500 yards above the Arley Mine, the recognized base of the Middle Coal Measures of Lancashire.

In answer to my enquiries, I have been favoured by Mr. Herbert A. Woodward with particulars of some recent boulders found in the deep mines of the Clifton and Kersley Collieries, near Manchester, many having been found in the upper mines previously of which no public record exists. He reports that they are found in clusters as a rule, but in a few instances, singly. He says they are common to all seams of this district, but are most plentiful in the Trencherbone seam, which corresponds with the 6 feet or 9 feet seam of the Wigan district.

They are found in the coal, in the roof, and sometim
half imbedded in both coal and roof, at depths of 720, 1
and 1800 feet from surface.

There are no special signs, either in the coal or roof,
show under what circumstances they were deposited;
position of some of them in the Measures is shown in
sketch. They are all rounded and water worn, and are
weight from 1 lb. up to 16 cwt. (1792 lbs.)

The latter is of extraordinary size, and far exceeds
hitherto found (see sketch A B). It was one of three bould
(the smallest of which would weigh 5 cwt.) found in a gro
in driving a tunnel from the Doe Mine to the White Mi
at a depth of 240 yards from the surface. They were
found in the coal, but in a bed of dark blue metal in
Measures overlying the Doe Mine.

Two of these have been destroyed, but they are suppo
to have been similar to the remaining one, which is a h
dark-coloured grit, not quartzite.

Another is noted from the Trencherbone coal, at a de
of 350 yards from the surface, weight about 60lbs., lying
the top of the coal, in which it was half embedded, a
covered by the soft blue metal roof. (See sketch C.)

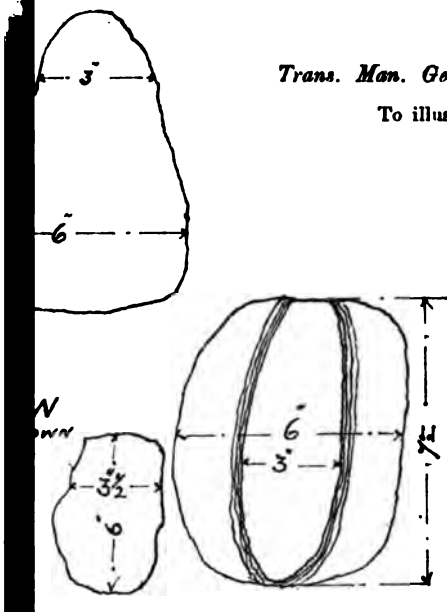
A group of three others, as seen in the sketch D, are em
bedded in the solid coal of the Trencherbone seam, and re
on a thin parting in the coal of a quarter of an inch thick
smudge. Mr. Woodward says that a smooth "slickenside
surface surrounded each of the boulders, and they appear
as if the coal had been run round them like asphalte. The
three are all quartzite, and were found at a depth of 18
feet from the surface.

All the boulders mentioned come from the Middle Co
Measures of Lancashire, from the Arley Mine at the base
the upper part of the Middle series.

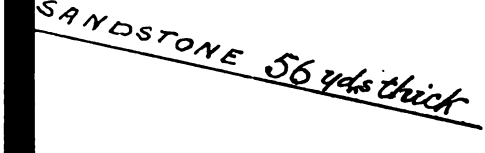
Some interesting boulders have been recently found in

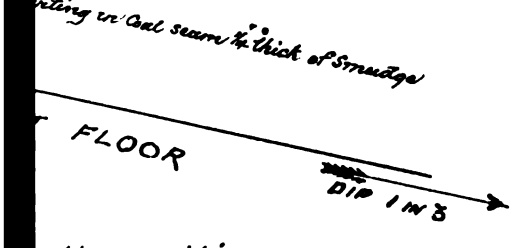
Trans. Man. Geo. Soc., Part XVI., Vol. XIX

To illustrate Mr. Stirrup's Paper.



he 3 Boulders below giving their dimensions





the position in the seam found: smallest 1 lb. heaviest 40 lbs Quartzite

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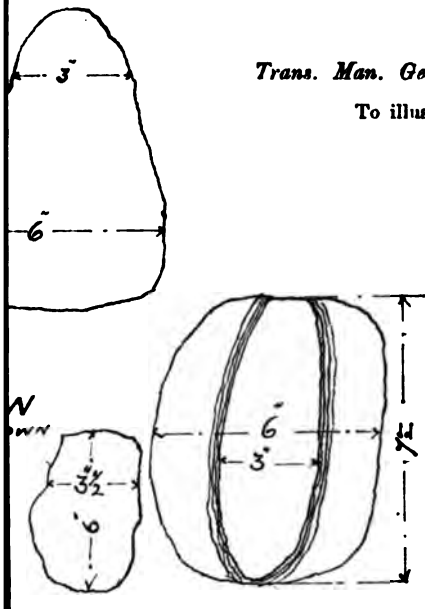
feet from the surface.

All the boulders mentioned come from the Middle Coal
Measures of Lancashire, from the Arley Mine at the base to
the upper part of the Middle series.

Some interesting boulders have been recently found in the

To illustrate Mr. Stirrup's Paper.



he 3 Boulders below giving their dimensions

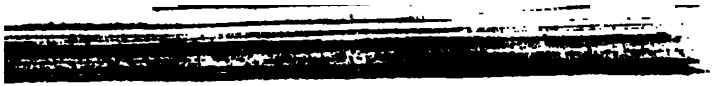
SANDSTONE 56 yds thick

rting in Coal seam 1½" thick of Smudge

FLOOR

DIP 1 IN 8

the position in the seam e found: smallest 1 lb. heaviest 40 lbs Quartzite



Lower Coal Measures of Lancashire at Bacup; they are, however, of rarer occurrence in the Lower Coal than in the Middle Coal Measures.

In the "Old Meadows' Pit," belonging to H. H. Bolton, Esq., about 70 to 80 yards from the surface, was recently found a well-rounded, almost globular boulder of granite, measuring 16 inches in circumference, and weighing 6¼ pounds. It lay embedded in the roof, which is a hard sound rock, close to the top of the coal, which is known as the Gannister Coal or Mountain Mine, upwards of 1000 feet below the Arley. This specimen, which is a very interesting one, I shall refer to again when reading a few remarks upon it by Professor Bonney.

Portions of two smaller boulders from the same mine have recently come into my hands. They have the same rounded outlines, with a coating of carbonaceous matter; one is composed of angular grains of quartz, largely impregnated with sulphide of iron; the other is a dark gray quartz felsite, similar to rocks found in the Lake District.

These boulders and the granite one were taken from a depression (Horse rig) which runs through the Old Meadows' Pit, and which continues through other coal pits on the hill side in the direction of a pit called the "Moorcock," at the head of Walsden Valley. Though taken from the same depression, they were separated by some distance from each other.

Mr. George Scott, in reference to these boulders, says they are not plentiful, he having only met with four or five during many years' acquaintance with the pits. Some are of quartzite, but all are covered with a thin film of coal, and they occur, as a rule, singly, on the top of the coal, or sometimes partly imbedded in it. No large ones have been found in this neighbourhood, those noticed being from 1 lb. to 6 or 7 lbs.

Mr. Scott also informs me that some ten years or more ago, a red granite boulder, of small size, was found in the Sand Rock Mine, about one mile from Bacup, a thin coal in the uppermost Millstone Grit or Rough Rock. It was covered with a thin film of coal, and had the usual rounded contour. This specimen has, however, been lost.

Boulders such as I have mentioned, consisting of extraneous rocks imported into the neighbourhood, are by no means confined to the Lancashire Coal Field; similar instances have been recorded from the Leicestershire Coal Field by Mr. Gresley, and by other observers from North Staffordshire, the Forest of Dean, South Wales, and other of our English coal fields.

Mr. Kidston informs me that they are absent, so far as is known, from the Scottish coal field.

Another important fact to bear in mind in considering the distribution of these puzzling boulders is, that they are not restricted to the Coal Measures of England only, but they are met with on the continent of Europe, in the Coal-beds of Saxony, Upper Silesia, Austro-Silesia, and elsewhere.

Since bringing this subject before the meeting of the British Association in our City in September last, Mr. Robert Kidston, F.G.S., has drawn my attention to a paper, entitled "Gerölle in und auf der Kohle von Steinkolenflötzen, besonders in Oberschlesien" (on Boulders in and upon the Coal of Coal Seams, especially in Upper Silesia), by Ch. E. Weiss, of Berlin, in the *Jahrbuch der Königlich Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin für das Jahr, 1885.*

In this paper, Weiss quotes the investigations and opinions of Herr D. Stur, embodied in a memoir entitled "Uber die in Flötzen reiner Steinkole enthaltenen Stein-Rundmassen und Torf-Sphärosiderite" (Jahrbuch d. k. k. Geol. Reichsanstalt zu Wien, 1885, S 613) (On Seams of

Pure Coal containing Rounded Stones, &c.) where a catalogue is given of all the then known occurrences of boulders in coal seams on the continent and elsewhere, including the earlier discoveries of Römer.

These boulders, from various coal pits in Austro-Silesia and Upper Silesia, recorded in the memoirs just mentioned, have the same outward characteristics as those found in the English coal beds, having for the most part the same rounded outlines, with a smoothed and polished surface; except in some of the granulite boulders, which exhibit a certain roughness due to the small garnets they contain standing out from the general mass, a circumstance no doubt due to weathering, and as Herr Weiss justly remarks, this affords no argument against their being boulders.

These rounded stones all belong to ancient crystalline or metamorphic rocks, and are classified as Gneiss, Granitic, Quartz-Porphyry, Granulite, Quartzite, &c.; they vary in weight from about 1 lb. to 7 lbs. as a rule. One instance, however, is recorded of much larger size, from Kattowitz, in Upper Silesia, this is the largest known boulder recorded by the German authors. It is a typical Granulite,* lenticular in shape, weighing 55 kilogrammes, *i.e.*, about 121 English pounds. It measures 50 centimetres in length, 35 centimetres in breadth, and 20 centimetres in thickness.

In an appendix to the paper of Herr Weiss, he mentions that in August, 1885, according to an account in *Mittheilung des Königl Oberbergamtes zu Breslau*, another discovery had been made in the Caroline Seam of the Hohenlohe Colliery, Kattowitz, Upper Silesia, of a group of ten boulders.

The largest weighed about 80 kilogrammes (176 lbs.),

* *Granulite* is a schistose rock, consisting mainly of orthoclasse felspar and quartz, with small grains or crystals of red garnet disseminated through the mass. This rock occurs, associated with other crystalline rocks, in the mountainous regions of Saxony, Bohemia and Moravia.

others 25 and 20 kilogrammes (55 and 44 lbs.), but of these no description has yet been given.

Herr Stur in his paper seems to have some doubt about these *Stein-Rundmassen*, having any reason to be regarded as boulders, although he does not ignore their similarity to known rocks. He seems rather to argue for their being concretionary bodies, and compares them with what are known to us by the name of coal-balls or bullions, which are undoubtedly concretions, due to the various mineral substances disseminated through them. "Of course," says Herr Stur, with evident candour, "one cannot say truly that this is so," yet he seems to see no other way of explaining their presence.

The hypothesis of the transport of these stones by floating trees, seems to him incompatible with the "colossal weight" of such pieces as that weighing 55 kilogrammes.

Herr Weiss, on the other hand, sees no obstacle in the weight of these boulders to militate against the assumption of portage by floating trees, for he says, "it now appears that a weight of several hundredweight is absolutely not too high for such a means of transport, for certainly at that time, there were trees big enough to bear such loads in the water without sinking."

Further, he says, "it is not directly necessary to assume that they must have been the interlaced roots that held fast such stones and carried them away, as even the thick branches would be able to sustain them, if they once fell into the same, from any steep banks, while drifting by, and thus they might be floated onwards by wind gradually to far distances, until the raft became rotten and allowed its too heavy freight to sink."

Herr Weiss, while strongly supporting the view of these rounded stones being true boulders in opposition to Stur's opinion, is evidently a strong adherent to the drift-wood

theory as an explanation of their distribution, for he says, in another part of his paper, "If one assumes the explanation of the transport of these boulders by trees one is reduced to the agency of drift-wood, and one may arrive at the conclusion that the coal measures consist generally of such transported material, instead of plants grown on the spot, which latter opinion is the most general one at present. But in truth, it will not be necessary to deprive oneself of the advantage of this explanation, by denying the possibility of a partial transport of foreign coal forming materials by means of drift wood, which have landed now and then these stony strangers. In all cases the drift is a subordinate phenomenon; but entrances from the open sea to parts occupied by the coal flora must have been existing there, especially when we find such witnesses of travel at that period, even distant journeys of loads, such as those shown by the deposit of these (*Mark Steine*) landmarks."

Herr Weiss touches upon another point in the history of these boulders, *i.e.*, their distribution in time or in the vertical series of the coal-measures.

Attempts have been made by several continental geologists to ascertain and determine the relative age of the various coal seams of detached coalfields by a consideration of their fossil flora.

This work of stratigraphical botany has been done for the Loire coalfield of Central France by M. Grand Eury, by M. Gosselet for Northern France and Belgium, and for portions of Germany by Goeppert, Geinitz, and others, but no similar attempt has yet been made to classify our English coal measures.

Now it appears from the evidence of Weiss that certain of the coal seams, which have furnished these stray boulders in Austro-Silesia, have been identified by their flora with other boulder-yielding seams belonging to widely separated

coalfields in Upper Silesia. Presuming then, this identification to be correct, it would follow that the transport and deposit of these boulders took place somewhat about the same period or within not very widely separated limits of time.

This period, according to Stur, and adopting Geinitz's classification, would appear to correspond with the uppermost part of his Sagenaria-zone (Lepidodendron veltheimianum), which, according to Grand Eury, would belong to the lower group of the middle coals.

Turning now to the question as to the probable place whence these before cited boulders were derived, Weiss says their composition corresponds to a certain extent with that of the rocks composing the nearest situated older mountains.

"That the Upper Silesian boulders, which consist for the most part of Granulite, came from the great 'massif' of old crystalline silicate rocks of Bohemia, which stretch over large tracts of the neighbouring countries of Saxony, Silesia, Moravia, &c., appears certainly very probable."

And again, he says, "a very important fact to obtain a clue to the derivation of our Upper Silesian coal boulders is the geographical position of the places where the discoveries have been made. These collieries lie, generally speaking, in a straight line of about 70 kilometres (43 miles) from north east to south west. This line points to their south-westerly prolongation in the district of Brünn, in Moravia, whence, particularly from Namiest, west of Brünn, Granulite has long ago been known. The distance from Namiest to Ostrau (one of the most southerly of these collieries) is about 170 kilometres (105 miles). Though there may be in the position of these given points no fixed proof for the transport of the boulders from S.W. to N.E., and for so long a distance, yet it is quite within the range of possibility that in this direction, floating trees, laden with

a freight of stones, have been carried far above 200 kilometres ere their burden sank."

The verification of this hypothesis depends, he says, upon further research among the rocks of the Bohemian mountain ranges, and also upon a closer petrographical investigation of their constituents.

Having reviewed the evidence afforded by these European and British examples we will now cross the broad Atlantic to the North American Continent, and we shall find that we have similar evidence forthcoming from the coal seams of the United States. If we regard the character and the composition of the American boulders, and their position in the coal beds, we find them to accord in all points with those of our own country, and the description given of them by American geologists would very well apply to our own. Professor Orton, State Geologist of Ohio, to whom I am indebted for references and specimens, says, these boulders, though uncommon, are still in the aggregate numerous, and remarks that all he has seen agree in mineralogical characters.

In the Geology of Ohio, Vol. 5, it is stated "that a boulder of metamorphic sandstone, apparently derived from the Cambrian rocks of the Appalachian border to the southwards, was taken from the thick coal at Shawnee, just above the second slate.

The coal was normal in all respects above it. The boulder weighs not less than 200lbs. The surface of the boulder appears glaciated, and ice transport would seem almost a necessity for such a block."

In the Report of Progress, Ohio Geological Survey for 1870, Professor Andrew gives the following account of a quartzite boulder, found partly imbedded in the Zaleski coal: "The boulder was worn and smoothed by friction before it came into the coal. Such boulders are not

infrequently met *in*, and immediately *above*, the coal. One of the miners states that in a few cases he had found a number together, sometimes 8 or 10, in the coal, and that single ones are often found.

One of these is a gray quartzite, compact and firm, well polished externally. Some of them are found entirely bedded in coal, but more occur in the shales immediately above the coal, but so close that they come down when the coal is taken."

Another boulder is mentioned from the Zaleski coal, as follows:—"Very hard gray quartzite, rounded and worn by friction before coming into the coal, in which it was found half imbedded, and the other half in the overlying shale."

The dimensions are given as being not far from 17 inches in the longer diameter, and 12 inches in the shorter.

From the same seam in Perry County a boulder of gray quartzite weighing not less than 400lbs. was taken. It rested on the main parting.

So far as I can learn these American boulders appear to be confined to a special horizon in the Ohio coalfield, that of the Middle Kitanning coal.

The boulders specially referred to, come from two localities 30 or more miles apart, and the exceptional character of these coal measures, as containing erratics, has been used to enforce the claim of the disputed identity of the two coalfields.

I have, by the kindness of Professor Orton, specimens of three of these gray quartzite boulders from the Kitanning coal of Shawnee and Zaleski, and from their similarity to each other and to our Lancashire boulders, they are particularly interesting and remarkable.

I have had thin sections prepared of these Ohio boulders, as well as of some of our Lancashire ones; they have been submitted to Professor Bonney, who has most obligingly examined them and remarked upon them.

Without going into the details of the mineralogical composition given in his notes, I may say that he classes four of the boulders from the Roger mine, Dukinfield, as ordinary hard grits, rather earthy, or ferruginous. They have a "dirty" appearance under the microscope, and Professor Bonney says "are composed of more or less subangular fragments of quartz, very variable in size, which from their occasional mineral enclosures I should suspect came from old granitoid rocks, probably some Palæozoic grit."

Of the sections from the American boulders of the Ohio coalfield, Professor Bonney writes that they have the same general characters as the Dukinfield boulders, but a little more distinctly cemented by secondary quartz.

Of one, which he states might be better called a Quartzite, he says, "some of the grains are rather well rounded, contains a grain or two of tourmaline; it rather reminds him of some specimens of coal boulders he had seen from Leicestershire, Staffordshire, and elsewhere."

Summing up, Professor Bonney says, "Of these, most tell us nothing beyond the fact that they are no doubt Palæozoic rocks, and have probably derived their materials from old granitoid rocks.

"The 'granite' specimen, he says, is interesting, it is a rock more ancient than the carboniferous, and the rounded inclusions of quartz in the felspar is a thing which is specially common to the granitoid rocks of the Hebridean series of Britain and the Laurentian of America.

"But of course, I cannot assert it is Hebridean, only it reminds me of Hebridean."

From the foregoing facts you will gather that the presence of these foreign boulders in coal seams opens out several interesting enquiries.

The two main questions are, as previously pointed out:

Whence did they come, and by what means were they brought into their present position?

Many suggestions have been hazarded and theories broached to answer these questions, but none, as yet, fully accounts for all the phenomena connected with these boulders.

We have seen that they are not confined to our own little island, but are found under exactly similar conditions in Europe and North America. So whatever the agent of transport was, whether water or ice, it was evidently active over a large part of the Northern Hemisphere.

The similarity and almost identity of the mineralogical composition of the American boulders with many of our English ones, is very remarkable, coming as they do from areas so widely separated as are our own shores from those of America.

These boulders are evidently older than any rocks of the Carboniferous period, but whether they are fragments of some ancient continent of Cambrian or Archæan age has yet to be decided.

As to the mode of deposition of these boulders in the seams of coal, many objections surround the theory of transport by driftwood or by currents of water, seeing the great size of some of these blocks, and the total absence of any associated clays or sands.

Transport by ice, floating icebergs in a summer sea, would perhaps explain better than any other theory, their position and often isolation, in strata, which indicate quiet deposition, and which are singularly free from any admixture of extraneous matter.

When one examines the composition of the rock forming the roof of these coal seams, we find it to consist as a rule of fine sediments, such as might be deposited by a gently flowing stream, whose force would be utterly unable to transport such heavy burdens as these boulders.

Yet we find these boulders dropped here and there, evidently by some abnormal or exceptional agency, which does not appear to have disturbed or arrested the continued increase or deposition of these fine muds.

We know that rain storms of unusual severity in mountainous regions are able to displace and move large stones or masses of rock to a considerable distance, also that icebergs often act as carriers of such like freight, hence we seek in some such agencies as these the solution of the question under consideration.

We have seen that these boulders have a wide distribution in space, but in time they seem to be limited to periodic appearances only (so far as our present knowledge goes)—a supposition which appears to be supported by the records of their occurrence in the Lancashire coal seams.

In the Lower Coal-Measures Series of Lancashire, in the Gannister Coal, we find the occasional appearance of a far-travelled boulder, such as the granite ones referred to, and then no evidence of their occurrence during the long lapse of time represented by the interval between the Gannister Coal and the Arley Mine, a distance in vertical thickness now represented by 300 to 350 yards of strata.

Then we have their appearance in the Arley, the base of the Middle Coal-Measures, in which the boulders are mostly small, mere pebbles in many cases, and then again, still later in time, and higher in the series (a period whose duration is measured by the thickness of 300 to 350 yards of intervening strata), we have the Trencherbone Seams, which have yielded these boulders in greater number and size than any other of our Lancashire coal seams.

A long break now intervenes until we arrive at somewhere near the top of the Middle series of Lancashire (whose whole thickness is estimated at 975 yards from the Arley

Mine to the Worsley 4 feet coal), where we have the Roger coal of Astley, Dukinfield, which, though not thoroughly identified with the Shuttle and Crumbouke 4 feet of Pendleton, Mr. J. Dickinson, H.M. Chief Inspector of Mines, thinks they do correlate, as also with the Upper 3 yard of Radcliffe, in all of which boulders have been found.

Professor Croll in his "Climate and Time" suggests that the Carboniferous flora was the growth of one of those assumed interglacial stages, recurrent during all geological time, and that during the intervening cold periods, represented, I presume, by the grits and sandstones, we had the most favourable conditions for entombing and preserving the vegetable life of the epoch.

But an objection to this theory is, there is nothing in the character of the vegetation during the whole of the long period embraced by the Coal Measures to support the argument.

The flora is identical in character and indicates no change of climate during the milleniums of milleniums represented by the thousands of feet of thickness of the Coal Measure rocks.

Such are some of the unsolved problems represented by these boulders, and nothing but a careful accumulation of facts with regard to them, such as a microscopical examination of their lithological characters and mineral constituents—their comparison with similar rocks *in sitû*,—observation of their mode of occurrence and distribution in the Coal Measures,—will help to unravel their mysterious history.

Professor Boyd Dawkins said: At this time of the evening I cannot say more than a few words upon the subject before the meeting. It seems to me that the ice theory is a theory which would hardly account for the problem of the existence of these stones in the Carboniferous

strata. For us to imagine that there were fleets of icebergs careering over this country during the time when those wonderful carboniferous forests were flourishing, seems to me altogether a mistake and quite impossible. The vegetation is that of a warm climate. But we have evidence, other than that offered by the trees of the carboniferous age, with regard to the climate, in the enormous spiders like the tree-spiders of Brazil, and scorpions, also, widely spread in the continental deposits—and they have been found also in England and in America—it seems to me the ice theory would hardly account for the transport of these big stones. On the other hand it is undoubtedly very difficult to suppose conditions under which stones weighing many hundred-weights could be carried in the roots of trees; but when I read of the enormous blocks of vegetable material which sometimes accumulate in the lower regions of the Mississippi, it is just conceivable that by some accident, one of these blocks might have got a ground close to one of the bluffs at the bend of a stream, and that bluff may happen to have been composed of large masses of stone—I can quite suppose that, in like manner, large stones may have been conveyed very considerable distances. With regard to the local distribution of these foreign materials, I would first point out that they are not only found in the shales, and in the coal, but with other foreign materials they occur also—unmistakeably so—in the sandstones. For instance, in the red rock in the neighbourhood of Bacup, garnets have been discovered; and I take it, therefore, the whole sum and substance of the evidence they present, as regards the source from which they were derived, is that these fragments of granite, quartzite and the like, came from some area in the North. It may be the area of Southern Scotland, but more probably it was the area of the Highlands, or a continuation of that area which, for a long period in geological history,

Manchester Geological Society had for its object the furtherance of the true interests of mining and geology and knew nothing of party politics. I was able to assure him, as I now assure this meeting, that there will be no infringment of that regulation on my part, and I shall endeavour successfully, as I believe, to express my views without a tinge of partisanship. I know no better way to prevent such questions becoming of a party character than by eminent neutral organisations like mining institutes taking them in hand.

Mining Questions are National Questions.

It need not be contended at a meeting in which mining interests are so largely represented that anything which vitally affects the mining industry is a national question. There are no means of ascertaining with accuracy, at any rate none at my command, the amount of capital invested at the present time in the United Kingdom; probably I am not over estimating in fixing the amount at one hundred millions sterling. We do know from the statistics now so carefully prepared each year and published under Government authority, that the number of persons employed in and about our coal and metalliferous mines is about six hundred thousand. The position industrially which England has made among the nations of the earth has been by reason of and depends on the continuance of her vast mineral resources. These, once the property of the nation, have been lost through lack of knowledge that they existed, or by carelessness on the part of our State authorities. A correspondent in Scotland sends me a Scottish newspaper of very recent date* containing a letter headed "The Law Appertaining to Mines and Minerals." The writer of that letter makes reference to "The Act concerning the Mines," passed in 1592, under James VI., dealing with the mines,

*_The Scottish Leader_, 20th February, 1888.

then stones were brought over and dropped upon that lower deposit. It seems to me very unlikely that the quiet settling of a boulder would cause it to go very far into the vegetable matter—certainly not to a depth of two or three feet. If the coal in which the boulders are said to have been found embedded is one homogeneous seam, deposited without interruption, then these stones have penetrated further than I should have expected. On the Arley Mine at Burnley I have found deposits of small pebbles, without any intermixture of large stones, the majority of them being not any bigger than horse-beans. It has been suggested that the large stones are mere concretions. Such a theory could only apply to the rounded ones. It is entirely disposed of, in my judgment, by the presence of the angular ones. As to the mode of transport of these stones I have formed no positive judgment at present, and rather attribute it to floating ice.

Mr. RADCLIFFE pointed to the difference in structure between one of the boulders from the Trencherbone mine and another—the one being quartzite and the other a much purer quartz. As to the origin of these boulders, he said the question was beset with difficulties. In the case of a deposit in his own neighbourhood he had observed a number of grooves which ran pretty nearly parallel to the line of boulders, and he was disposed to think that between those grooves—which extended from the roof down into the coal something like 18 inches or 2 feet, and varied in width from 18 inches to 3 feet 6 inches, and in length from 4 to 500 yards—and the boulder deposit, there was some possible connection.

The PRESIDENT said: From the way in which Professor Dawkins disposed of the theory as to ice transport, the cautious way in which Mr. Wild reserved his opinion, and the clear way in which Mr. Radcliffe has described these groovings and their possible connection with the boulder

maintaining one-tenth of the population, but is associated in the closest degree with as many more of the population who are engaged in the iron and steel and engineering industries; and in a secondary degree with our engines on land and our ships on the sea, and our numberless manufactures. Whilst relief to mining relieves and encourages the kindred industries, burdens upon mining have an injurious influence upon all with which it is connected.

Condition of Mining in the United Kingdom.

What is the condition at the present time, and what has been the condition for many years past of mining and kindred industries in England? I have the honour of addressing those who know, and who can correct me if I am wrong. The records of half a generation are most melancholy, and balance sheets are sad and sorrowful documents. I have had before me whilst writing this paper the latest financial statements of three of the most important mining companies in the United Kingdom, and representing a combined capital of several millions sterling. Two of the concerns made a few thousand pounds of profit, but, placing the three statements together, the net result is an actual loss. Wages are low, and I should certainly be exceedingly sorry if it should be found necessary to make still further reductions in the remuneration of a dangerous occupation which is entitled to reasonably good pay. There are some collieries yielding a profit, but there are at least as many working at an absolute loss; and I believe that, taking all the collieries and mines of the United Kingdom, and making sufficient allowances for depreciation, very little indeed of profit is being made to those who have invested their capital. Mr. Alfred Hewlett, the managing director of the Wigan Coal and Iron Company and who is an authority upon mining matters second to none in England, in the course of his evidence before the Royal Commission on the depression in trade, which we shall have

I feel quite confident they are—got into the coal seams is one very difficult to answer. I do not think we have yet arrived at a sufficient knowledge of these things to be able to give any explanation that will cover all the difficulties which present themselves. To call these specimens of rocks concretions, adds nothing to our knowledge, and I would like to ask the President how, on his hypothesis, he would account for their special characters and mineral constitution, as they differ totally from these undoubted concretions which are met with from time to time in coal, chalk, and other rocks. The very diversity of composition of the boulders, which I have cited, from the Austro-Silesian coal field, where the individual boulders are not so much alike as we have them here, for they have Granites, Gneisses, Quartz-Porphyries and other rocks equally distinct, is a fact which tells against the concretionary hypothesis. The German geologists, moreover, have had sections made of the boulders taken under precisely similar conditions to our own, and have examined them microscopically. They find that they are composed of a certain number of minerals; and they can go to the rocks —those ancient crystalline rocks of Bohemia—and tell you from an examination of the rock *in sitû* that it is exceedingly probable that such and such a specimen came from that mountain range. Its exact source, of course, it is impossible to tell; but there is such a correspondence between the boulder taken out of the coal and a special range of mountains of well-known petrological character that it seems to me, you cannot really, in such cases as that, consider them to be concretions. You can trace the path of the boulders, almost step by step, across the plain from those ancient mountains which possibly stood much higher at the time when the coal measures were deposited than they do now. It seems to me to be a case of closing

the eyes to such welcome light as is thrown upon these questions by the aid of the microscope—the efficiency of whose assistance in a solution of this question cannot be ignored. The obscurity that surrounds the place of origin of these boulders also envelopes the question of their mode of transport. As to the drift-wood theory of transportation I think it is not an improbable one, although we lack data as to the capacity of drift-wood to bear such heavy loads as the masses of rock I have mentioned. There may have been storms whose magnitude and power we cannot now gauge; and the circumstances mentioned by Mr. Ratcliffe of groovings in the coal in his district, along the line of the boulder deposit, very probably had, as he suggests, some connection with that deposit, although in the majority of cases no such signs of disturbance either in the coal or shale are visible.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XIX. SESSION 1887-8.

The ORDINARY MEETING of the Members was held on Tuesday, March 6th, 1888, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOSEPH DICKINSON, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society, namely:—

Mr. S. A. OLIVER, King Street, Wigan.

Mr. OSWALD WALMESLEY, Westwood House, near Wigan.

THE GRANITE OF THE MULLET, IRELAND.

Mr. CHARLES HARDWICK exhibited a picture, in black and white, of the laminated granite rocks of Mullet Head, in the West of Ireland, together with specimens of the rock. He said that Mr. Robert Pollitt, the artist, in the course of a tour in the West of Ireland, came upon the rocks in question, and was so interested in their peculiar structure, that he made the sketch now exhibited, and also brought away the rock specimens. These he had handed to him (Mr. Hardwick) in the hope that they might interest the

members of the Geological Society, and he presented the sketch and also the specimens, to be placed in the Museum at Owens College, if it was thought fit so to dispose of them.

Mr. HARDWICK then read the following note on the Termon Granite in Mayo, Ireland, by Mr. Robert Pollitt:—

The accompanying specimens of granite are from a hill, composed entirely of it, at the south-eastern extremity of "The Mullet," a peninsula in the County Mayo, Ireland. The rock lies in layers of varying thickness, from a few inches up to from three to four feet, intersected by longitudinal vertical joints at various distances, from two feet up to seven or eight feet, and by other vertical rectangular joints occurring at distances up to 40 feet, so that the entire mass is practically divided into fairly rectangular blocks of all sizes and proportions.

It is mainly composed of felspar, quartz, and (black) mica. And the colour varies from red on the northern side, to grey on the southern side; the central part of the hill being of a colour composed of both—an intermediate tint.

The PRESIDENT said he understood that some of the members were acquainted with the locality referred to. Perhaps they would say something in reference to the communication.

Mr. HOLLINGWORTH (Hon. Sec.) said that Mr. Burnett visited the West of Ireland about eighteen months ago, at the same time that he (Mr. Hollingworth) did, and he understood that that gentleman had intended writing a description of the peculiar granite formation of The Mullet. The rock was really wonderful. The granite was in layers, some of them not more than three or four inches thick, whilst others were said to be nearly four feet; he, however, saw none of a greater thickness than 3 feet. It was divided by vertical or nearly vertical joints. The stone was cut into blocks ready for use, and the quarrying

inflation soon came to an end; we had taught our customers a lesson—they became our competitors and commenced a development of their several resources, which development has gone on with increasing force ever since, and, so far from having spent itself, that competition in the future will be even keener than in the past. We have already mentioned that in 1854 England made as much iron as all the rest of the world combined. Even in 1874, towards the end of our brief period of inflation, England's production of pig iron was nearly half the production of the world, the exact figures being forty-seven per cent. Now, taking last year as a basis, we only produce only one-third of the total production of pig iron. Of manufactured iron we produce one-fourth of the total production. Of steel in all its branches we produce only one-third of the total production. And, taking as a very remarkable illustration the now popular method of manufacturing steel by the basic process, the invention of eminent Englishmen. This method of manufacture commenced ten years ago, and has now grown to 1,377,000 tons annually, of which we in England, the country of its invention, and the foremost iron and steel nation of the world, only produce one-fifth, that is, for every ton of basic steel which England makes, other countries make four tons. The prosperous period gave an impetus to social legislation, mines Acts, and mines amendment Acts followed each other, increasing, and substantially too, the price of coal getting. I have endeavoured to arrive at what actual burden has been imposed by mines Acts including 1872 and 1887. It was stated before the Royal Commission that ironmasters in Scotland charged it with between three and four shillings on a ton of pig iron, but this was evidently an exaggeration. Mr. Hewlett in his evidence said that unfortunately every Act of Parliament relating to mining had increased the cost of working, and he estimated the

shown on Plate 3, attached to his paper. *(See Part XIII., Vol. 19.)*

Mr. Simpson had also been good enough to send a copy of one of Mr. Hall's reports or memoranda having reference more particularly to the iron ore found in that part of the field covered by Plate IV. It will be seen from the section exhibited that the beds are of considerable thickness. It would have been interesting to have given the report in full, if we had had the samples to which it refers, but the reference to natural coke may throw some light upon the manner of the formation of that peculiar mineral which passes without any trace of a fault into a bed of soft black clay. The report says, "The total depth of the shaft from which the "ore was taken is 30 feet, viz. :—

	Ft.	in.
First bed	9	0
Parting	0	2
Second bed	17	0
Soft black clay..	4	0
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"The *soft black clay* under the ironstone bed in this shaft "is changed into a natural coke in a shaft 15 yards to the "east or rise side of the strata, as per sketch."

It might have been mentioned in the paper that where coal is worked under royalty (which is very seldom in this field) the royalty is 15 cents (7½d.) per ton on every 2000 lbs. sold. The value of the freehold, including minerals is (where the coal is not actually opened) from £2 to £3 per acre.

The freight by ship from Bermuda Hundred to Boston is from 4s. to 7s. per ton, according to freights. The Grand Trunk Railway of Canada drew the coal for use on its New England section from this field, and four years ago the freight from Bermuda Hundred to Portland Maine on such coal was $1·75 (7s.) per ton.

Mr. HOLLINGWORTH asked if the "coke," so called, did not change into coal.

Mr. CLIFFORD: No; we trace it down into a seam of clay, as represented in that diagram. Between the two there is no intermediate state.

MINE RENTS AND MINERAL ROYALTIES.

BY MR. C. M. PERCY, M.E., F.G.S.

Some preliminary statement is necessary to explain why I should have undertaken to prepare a paper on

"MINE RENTS AND MINERAL ROYALTIES"

[by the term mine rents we mean fixed rents, by the term mineral royalties we mean payment per ton] to be read at the meeting of so important a mining and geological institute, whose members are probably nearly all in a position to know more of the subject than I do. The duty would certainly never have been volunteered by me, but I was pressingly invited by my friend, your excellent President, Mr. Joseph Dickinson, F.G.S., and H.M. Senior Inspector of Mines, and who after half a century of public mining life I congratulate on his occupying the Presidential chair in your year of jubilee. I was also encouraged to accept Mr. Dickinson's invitation by other eminent friends much engaged in mining matters, on whose advice I am able to rely. I have no expectation of being able to deal at all exhaustively with so important a subject, but shall be well content to open what may prove to be a useful discussion, and this should not be difficult, because in the Manchester Geological Society you have eminent men identified with mine lessors, mine lessees, and men like our inspectors of mines, who are identified with neither. In conveying the invitation to me your President, as was is duty, reminded me that the

united the North of Scotland with the Scandinavian Peninsula. It seems to me we must look in that direction for the source of these stones—that is, so far as relates to our own country. With regard to America, I would point out that exactly the same class of rock is found in the same relative position to the places where these stones occur in Britain; therefore we have, practically, the same conditions leading probably to the same results. None of these stones shows the slightest sign of glaciation, as far as I have been able to see. The great majority of them are slickensided. When a stone such as this is embedded in soft shale, or coal, and the whole is squeezed together, then you have the phenomenon of slickensides produced.

Mr. WILD, who was called upon for some observations, said: My ideas are scarcely matured yet with respect to these boulders. I have studied the subject a little, but I have not fully satisfied myself as to the manner of transport. That they are erratic boulders—washed and water-worn—I have not the least doubt; and from their quartzite character I have no doubt at all that they were derived from the older rocks. I believe, from the condition in which they are found, after being transported, they dropped through the water, quietly down upon the submerged vegetation and fish remains at the bottom; for I find on the underside of many of these stones what is evidently a thin film of fish remains; and there is also evidence of its having been pressed down a little into the coal. Some of these stones are said to have been found at the bottom or in the middle of the coal, but this I very much question. The proper position of these boulders is as represented in Mr. Woodward's diagram, at the top of the seam. If any have been taken from the middle of the coal, I think in those cases some change has taken place; there may have been a thin parting, indicating a distinct bed of coal which may have got under water and

then stones were brought over and dropped upon that lower deposit. It seems to me very unlikely that the quiet settling of a boulder would cause it to go very far into the vegetable matter—certainly not to a depth of two or three feet. If the coal in which the boulders are said to have been found embedded is one homogeneous seam, deposited without interruption, then these stones have penetrated further than I should have expected. On the Arley Mine at Burnley I have found deposits of small pebbles, without any intermixture of large stones, the majority of them being not any bigger than horse-beans. It has been suggested that the large stones are mere concretions. Such a theory could only apply to the rounded ones. It is entirely disposed of, in my judgment, by the presence of the angular ones. As to the mode of transport of these stones I have formed no positive judgment at present, and rather attribute it to floating ice.

Mr. RADCLIFFE pointed to the difference in structure between one of the boulders from the Trencherbone mine and another—the one being quartzite and the other a much purer quartz. As to the origin of these boulders, he said the question was beset with difficulties. In the case of a deposit in his own neighbourhood he had observed a number of grooves which ran pretty nearly parallel to the line of boulders, and he was disposed to think that between those grooves—which extended from the roof down into the coal something like 18 inches or 2 feet, and varied in width from 18 inches to 3 feet 6 inches, and in length from 4 to 500 yards—and the boulder deposit, there was some possible connection.

The PRESIDENT said: From the way in which Professor Dawkins disposed of the theory as to ice transport, the cautious way in which Mr. Wild reserved his opinion, and the clear way in which Mr. Radcliffe has described these groovings and their possible connection with the boulder

deposit, I am led to fancy that the whole question is begged by calling these things boulders. Anyone who studies the beautiful stratification that is met with in the coalfield must see that there has been no such interruption as this intruded into the formation. But we find freaks of nature occurring from the top of the highest series of rocks down to the lowest. We find substances which have taken particular shapes. The law of crystallography is one of the finest laws we know; in fact you may distinguish many minerals by the angle of their crystal alone. But all matter is not formed into crystals. The flints in the chalk assume a variety of forms. In the coal itself you have aggregations or concretions—generally sulphur in some form—and you can scarcely go, as I said, to any formation, from the highest to the lowest without finding matter assuming some particular shapes. These, I believe, to be simply freaks of nature assuming the form which it has been assigned for such matter to take. When Mr. Binney read his paper on these bodies, I ridiculed the idea of their being meteorites, as he supposed, and obtained for the Society a sackfull from the Roger mine at Dukinfield. I think it is unfortunate that aggregations or concretions should be here presented in the name of boulders. I should no more expect to find a boulder in the middle of a coal seam than I should expect to find one in the middle of a cocoa-nut.

Mr. STIRRUP in replying, said, I am sorry, Mr. President, that I cannot agree with the opinion which you have just expressed as to those substances being concretions, or in any sense of a concretionary nature. That nature has her "freaks" is undoubted, if by "freaks" we understand something abnormal, or not readily explicable; that there are many things connected with the formation of rocks, which we do not understand, is also quite certain, and the question as to how these boulders—for boulders

el quite confident they are—got into the coal is one very difficult to answer. I do not think ve yet arrived at a sufficient knowledge of these things able to give any explanation that will cover all the ulties which present themselves. To call these speci- of rocks concretions, adds nothing to our knowledge, would like to ask the President how, on his hypothesis, uld account for their special characters and mineral itution, as they differ totally from these undoubted etions which are met with from time to time in coal, , and other rocks. The very diversity of composition ie boulders, which I have cited, from the Austro- an coal field, where the individual boulders are not uch alike as we have them here, for they have ites, Gneisses, Quartz-Porphyries and other rocks ly distinct, is a fact which tells against the con- nary hypothesis. The German geologists, moreover, had sections made of the boulders taken under sely similar conditions to our own, and have examined microscopically. They find that they are composed of tain number of minerals; and they can go to the rocks ose ancient crystalline rocks of Bohemia—and tell you an examination of the rock *in sitû* that it is exceedingly able that such and such a specimen came from that ntain range. Its exact source, of course, it is impossible ell; but there is such a correspondence between the ler taken out of the coal and a special range of ntains of well-known petrological character that it s to me, you cannot really, in such cases as that, ider them to be concretions. You can trace the of the boulders, almost step by step, across the plain those ancient mountains which possibly stood much er at the time when the coal measures were deposited they do now. It seems to me to be a case of closing

the eyes to such welcome light as is thrown upon these questions by the aid of the microscope—the efficiency of whose assistance in a solution of this question cannot be ignored. The obscurity that surrounds the place of origin of these boulders also envelopes the question of their mode of transport. As to the drift-wood theory of transportation I think it is not an improbable one, although we lack data as to the capacity of drift-wood to bear such heavy loads as the masses of rock I have mentioned. There may have been storms whose magnitude and power we cannot now gauge; and the circumstances mentioned by Mr. Ratcliffe of groovings in the coal in his district, along the line of the boulder deposit, very probably had, as he suggests, some connection with that deposit, although in the majority of cases no such signs of disturbance either in the coal or shale are visible.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XIX. SESSION 1887-8.

The ORDINARY MEETING of the Members was held on Tuesday, March 6th, 1888, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOSEPH DICKINSON, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society, namely:—

Mr. S. A. OLIVER, King Street, Wigan.

Mr. OSWALD WALMESLEY, Westwood House, near Wigan.

THE GRANITE OF THE MULLET, IRELAND.

Mr. CHARLES HARDWICK exhibited a picture, in black and white, of the laminated granite rocks of Mullet Head, in the West of Ireland, together with specimens of the rock. He said that Mr. Robert Pollitt, the artist, in the course of a tour in the West of Ireland, came upon the rocks in question, and was so interested in their peculiar structure, that he made the sketch now exhibited, and also brought away the rock specimens. These he had handed to him (Mr. Hardwick) in the hope that they might interest the

members of the Geological Society, and he presented the sketch and also the specimens, to be placed in the Museum at Owens College, if it was thought fit so to dispose of them.

Mr. HARDWICK then read the following note on the Termon Granite in Mayo, Ireland, by Mr. Robert Pollitt:—

The accompanying specimens of granite are from a hill, composed entirely of it, at the south-eastern extremity of "The Mullet," a peninsula in the County Mayo, Ireland. The rock lies in layers of varying thickness, from a few inches up to from three to four feet, intersected by longitudinal vertical joints at various distances, from two feet up to seven or eight feet, and by other vertical rectangular joints occurring at distances up to 40 feet, so that the entire mass is practically divided into fairly rectangular blocks of all sizes and proportions.

It is mainly composed of felspar, quartz, and (black) mica. And the colour varies from red on the northern side, to grey on the southern side; the central part of the hill being of a colour composed of both—an intermediate tint.

The PRESIDENT said he understood that some of the members were acquainted with the locality referred to. Perhaps they would say something in reference to the communication.

Mr. HOLLINGWORTH (Hon. Sec.) said that Mr. Burnett visited the West of Ireland about eighteen months ago, at the same time that he (Mr. Hollingworth) did, and he understood that that gentleman had intended writing a description of the peculiar granite formation of The Mullet. The rock was really wonderful. The granite was in layers, some of them not more than three or four inches thick, whilst others were said to be nearly four feet; he, however, saw none of a greater thickness than 3 feet. It was divided by vertical or nearly vertical joints. The stone was cut into blocks ready for use, and the quarrying

was more like that of free stone than anything else. The stone varied in colour. On the north-east side the prevailing colour was red; in the centre it was a salmon colour; and at the south-west end it appeared to be grey. The specimens brought by Mr. Pollitt, and now exhibited, were, one of them grey and another of salmon colour. There did not seem to be any of the red rock. Those exhibited, however, were fair specimens of what the granite was like. It was now being worked to a small extent, but as a company was being formed for working it, it was likely to be quarried extensively. The rock stretches into the sea on the eastern side, but is cut off on the other sides apparently by faults; all the rocks of the district are metamorphic.

Mr. Stirrup (Hon. Sec.) moved a vote of thanks to Mr. Hardwick for his communication, and also to Mr. Pollitt for the sketch and specimens which he was so kind as to offer for the Museum. He had no doubt they would be thankfully received there.

The motion was seconded, and carried unanimously.

THE RICHMOND COAL-FIELD, VIRGINIA.

The President said the next business was the discussion of the paper read at a former meeting by Mr. William Clifford, on "the Richmond Coal-field, Virginia." The paper, he thought, was so exhaustive and complete, that it hardly admitted of much discussion.

Mr. Clifford said he had little to add to the information contained in his paper, but through the kindness of Mr. John B. Simpson, of Blaydon-on-Tyne, he was now able to show the section exhibited from actual sinking in one of the English company's shafts at Midlothian. The sinking referred to was a little to the north of the "deep shaft"

shown on Plate 3, attached to his paper. *(See Part XIII., Vol. 19.)*

Mr. Simpson had also been good enough to send a copy of one of Mr. Hall's reports or memoranda having reference more particularly to the iron ore found in that part of the field covered by Plate IV. It will be seen from the section exhibited that the beds are of considerable thickness. It would have been interesting to have given the report in full, if we had had the samples to which it refers, but the reference to natural coke may throw some light upon the manner of the formation of that peculiar mineral which passes without any trace of a fault into a bed of soft black clay. The report says, "The total depth of the shaft from which the "ore was taken is 30 feet, viz. :—

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By Mr. C. M. PERCY, M.E., F.G.S.

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[by the term mine rents we mean fixed rents, by the term mineral royalties we mean payment per ton] to be read at the meeting of so important a mining and geological institute, whose members are probably nearly all in a position to know more of the subject than I do. The duty would certainly never have been volunteered by me, but I was pressingly invited by my friend, your excellent President, Mr. Joseph Dickinson, F.G.S., and H.M. Senior Inspector of Mines, and who after half a century of public mining life I congratulate on his occupying the Presidential chair in your year of jubilee. I was also encouraged to accept Mr. Dickinson's invitation by other eminent friends much engaged in mining matters, on whose advice I am able to rely. I have no expectation of being able to deal at all exhaustively with so important a subject, but shall be well content to open what may prove to be a useful discussion, and this should not be difficult, because in the Manchester Geological Society you have eminent men identified with mine lessors, mine lessees, and men like our inspectors of mines, who are identified with neither. In conveying the invitation to me your President, as was is duty, reminded me that the

Manchester Geological Society had for its object the furtherance of the true interests of mining and geology and knew nothing of party politics. I was able to assure him, as I now assure this meeting, that there will be no infringment of that regulation on my part, and I shall endeavour successfully, as I believe, to express my views without a tinge of partisanship. I know no better way to prevent such questions becoming of a party character than by eminent neutral organisations like mining institutes taking them in hand.

Mining Questions are National Questions.

It need not be contended at a meeting in which mining interests are so largely represented that anything which vitally affects the mining industry is a national question. There are no means of ascertaining with accuracy, at any rate none at my command, the amount of capital invested at the present time in the United Kingdom; probably I am not over estimating in fixing the amount at one hundred millions sterling. We do know from the statistics now so carefully prepared each year and published under Government authority, that the number of persons employed in and about our coal and metalliferous mines is about six hundred thousand. The position industrially which England has made among the nations of the earth has been by reason of and depends on the continuance of her vast mineral resources. These, once the property of the nation, have been lost through lack of knowledge that they existed, or by carelessness on the part of our State authorities. A correspondent in Scotland sends me a Scottish newspaper of very recent date* containing a letter headed "The Law Appertaining to Mines and Minerals." The writer of that letter makes reference to "The Act concerning the Mines," passed in 1592, under James VI., dealing with the mines,

*_The Scottish Leader_, 20th February, 1888.

metals, and minerals of Scotland, and declared by Crown counsel so recently as 1885 to be "The Regulating Statute." The main provisions of this Act of Parliament are—First, that the right of all mines, metals, and minerals belong undeniably to the Crown; second, that a Crown officer, to be called the Master of Metals, be appointed, who should have all mines under his charge; third, that no private compact between the owners of the surface and lessees should be recognised without the consent of the Crown; fourth, that the Master of the Metals only should have power to authorise the working of any mine; fifth, that the owners of the surface should be bound to grant way leaves and ground for building, and be only entitled to surface damage. The writer of this letter argues that according to law all the mines, metals, and minerals in Scotland belong to the Crown as representing the community. Probably it will not be difficult to show either that this law has been repealed or that the Crown had absolute ownership and gave its right away. I express no opinion on the subject. The letter was sent to me while this paper was under preparation, and it seemed to me then as it seems still of sufficient interest and bearing upon our subject to be introduced. One cannot but have a passing feeling of regret that as a nation we might have received in hard cash a sum of money approaching within something like measurable distance of the enormous amount of our National Debt and have remaining for centuries to come an annual revenue of several millions. This cannot now be restored, and I am no advocate of or sympathiser with socialistic and communistic doctrines, but I am an ardent and consistent advocate of reforms under which we could so utilise the produce of the bowels of the earth to give the greatest amount of national good. The mining industry is not only directly important in itself with its six hundred thousand persons employed,

maintaining one-tenth of the population, but is associated in the closest degree with as many more of the population who are engaged in the iron and steel and engineering industries; and in a secondary degree with our engines on land and our ships on the sea, and our numberless manufactures. Whilst relief to mining relieves and encourages the kindred industries, burdens upon mining have an injurious influence upon all with which it is connected.

CONDITION OF MINING IN THE UNITED KINGDOM.

What is the condition at the present time, and what has been the condition for many years past of mining and kindred industries in England? I have the honour of addressing those who know, and who can correct me if I am wrong. The records of half a generation are most melancholy, and balance sheets are sad and sorrowful documents. I have had before me whilst writing this paper the latest financial statements of three of the most important mining companies in the United Kingdom, and representing a combined capital of several millions sterling. Two of the concerns made a few thousand pounds of profit, but, placing the three statements together, the net result is an actual loss. Wages are low, and I should certainly be exceedingly sorry if it should be found necessary to make still further reductions in the remuneration of a dangerous occupation which is entitled to reasonably good pay. There are some collieries yielding a profit, but there are at least as many working at an absolute loss; and I believe that, taking all the collieries and mines of the United Kingdom, and making sufficient allowances for depreciation, very little indeed of profit is being made to those who have invested their capital. Mr. Alfred Hewlett, the managing director of the Wigan Coal and Iron Company and who is an authority upon mining matters second to none in England, in the course of his evidence before the Royal Commission on the depression in trade, which we shall have

to refer to again, said that, going back thirty-five years, and including the inflated period of 1872-73-74, when coal was selling at famine prices, he was of opinion that mining had not on an average paid five per cent. on the capital invested. And within the last few weeks the able secretary to the Iron and Steel Institute, Mr. J. S. Jeans, who had exceptional opportunities of obtaining reliable information, because, if I mistake not, he is also secretary to the British Iron Trade Association, writes that "The condition of the English iron and steel industries for some ten or twelve years has been so depressed that the cases, in which it has been possible to pay a dividend of five per cent., have been conspicuous rather by their absence than otherwise. Some of the largest works have paid no dividend at all for years. Coal, the most indigenous of all English industries, appears to have fared no better. The highest authorities on the coal industry unhesitatingly assert that over the period of the past twelve years the trade, as a whole, has not returned two and a half per cent. upon the capital invested, and for this miserable 'mess of pottage,'" says Mr. Jeans, "we are working out as fast as we can the foundations of our prosperity as a manufacturing country."

Competition Abroad.

Nor do I see how any substantial improvement is to come about (except in one way, which we will mention soon). Prices may and no doubt will have minor elevations and depressions, but there can hardly be any permanent advance to a perceptible degree. We have great and enterprising and highly favoured competitors ever increasing in their competition, and our percentage of the world's productions is becoming less and less. Any comparison of what the various countries produced in coal and iron thirty years ago, and even fifteen years ago, and what they produce now, would prove this in a remarkable degree. In 1854 Eng-

land produced as much iron as all the other countries of the world combined; and that, as we shall endeavour to show presently, is certainly not the condition of things now. In one important article of manufacture, namely, pig iron, we have fallen from one-half to one-third of the world's production, not that England makes a less amount per year, we have increased, but not proportionately with other lands. The continent of America has boundless natural resources, which are being developed with marvellous rapidity. I have been reading a good deal lately in American papers, with which my many friends in the United States favour me, about the rise and progress of Pittsburg, which will in my opinion at no remote period become the greatest iron and steel making centre in the world. Even now the eminent American, Mr. Andrew Carnegie, tells us in a speech made last year whilst on a visit to England, that the works in which he is a partner and actively identified with its management will soon be able to produce half as much steel as all the steel works of the United Kingdom; and it is a fact that last year America made nearly as much pig iron as England, and the number of works is rapidly increasing. Some years ago the Pittsburg iron and steel makers had unlimited supplies of coal suitable to their requirements, and got so cheaply that it was delivered at the works at from half-a-crown to three shillings a ton. But now nearly every works in Pittsburg is using for all purposes of heating, steam generation, and illumination, natural gas, which is equally effective with coal and at about one-third of the price. Coal, to compete with it, would have to be delivered on the works at one shilling a ton. In these remarks on natural gas, I am quoting from a Paper read to our own Iron and Steel Institute, by Mr. Carnegie, in 1885. This month of March I have read an article in an American paper, in which a

leading American manufacturer said, that taking into consideration the efficiency of natural gas over coal, the latter fuel would be dear if delivered on the works free of cost. This wonderful fuel, known as natural gas, rises from depths of one thousand and thirteen hundred feet, and reaches the surface at a pressure of two hundred pounds per square inch. The delivery of increasing quantities has been going on for over 20 years, and can be piped away and used at a distance of many miles. In the month of February I was visited by two Mining Engineers and Colliery Proprietors from the State of Kentucky. In that State, the land with valuable timber and valuable coals, can be bought out and out for £1 an acre. And then our other competitors, such as France and Germany, are free from burdens which oppress England. I mention these points to show that a considerably increased demand cannot benefit England very much; there are others in the race, and either with advantages which we do not possess, or free from harassing influences which we do possess. Mr. Jeans writes that the English industrial can hold his own against the world if he gets anything like fair play. But he has to meet charges upon his industry which are not equally felt in countries with which he has to compete.

What Caused the Period of Inflation?

Many eminent authorities are agreed that our present and long-continued period of depression is attributable to the limited, very limited, period of inflation which commenced some sixteen years ago, and almost ended before it had established itself. That opinion I endorse. But there is not the same unanimity of opinion as to how exactly the inflation afterwards produced so severe and so prolonged a time of depression. When our good times set in, America had recovered from the temporarily ruinous and prostrating influences of her four years' civil war, and had plenty of

money, and enormous industrial demands which she could not anything like meet. Her iron and steel and engineering works, now equal to anything we have in England, were then only in their childhood. The Franco-German war had for more than a year completely paralysed the industries not only of the two nations, France and Germany, that were actually engaged, but all the Continental nations of Europe who, themselves, armed to the teeth, were watching the conflict, not knowing how soon they might be drawn in. When the war ended the industrial arrears had to be recovered. Germany had drawn a prize in the lottery of war amounting to two hundred millions sterling, and was ready to spend. France, which had expelled a dynasty and sacrificed two provinces, displayed a characteristic lightness of heart, and, rising like a Phœnix from its ashes, sent hundreds of millions of money into the national treasury. Other European powers also commenced to spend more or less. America was a great customer, and England became in very truth the workshop of the world. Demand was greater than the supply; prices went up by leaps and bounds; pig iron touched ten pounds a ton; coal passed a sovereign a ton, and we were threatened with a coal famine.

What Caused the Period of Depression?

I am afraid that we all thought that what, after all, was merely an incident was the commencement of an era; many of our safest men even lost their balance; all the minerals that could be leased were leased, and on landlords' terms, as they were masters of the situation. Mr. Hewlett, in his evidence before the Royal Commission, said that during 1872 to 1875 leases were granted on very much higher terms than before. Mr. J. T. Smith, of Barrow, before the same Royal Commission, said that during those memorable years iron ore on the west coast of England was leased on royalties as high as ten shillings a ton. The fleeting incident of

inflation soon came to an end; we had taught our customers a lesson—they became our competitors and commenced a development of their several resources, which development has gone on with increasing force ever since, and, so far from having spent itself, that competition in the future will be even keener than in the past. We have already mentioned that in 1854 England made as much iron as all the rest of the world combined. Even in 1874, towards the end of our brief period of inflation, England's production of pig iron was nearly half the production of the world, the exact figures being forty-seven per cent. Now, taking last year as a basis, we only produce only one-third of the total production of pig iron. Of manufactured iron we produce one-fourth of the total production. Of steel in all its branches we produce only one-third of the total production. And, taking as a very remarkable illustration the now popular method of manufacturing steel by the basic process, the invention of eminent Englishmen. This method of manufacture commenced ten years ago, and has now grown to 1,377,000 tons annually, of which we in England, the country of its invention, and the foremost iron and steel nation of the world, only produce one-fifth, that is, for every ton of basic steel which England makes, other countries make four tons. The prosperous period gave an impetus to social legislation, mines Acts, and mines amendment Acts followed each other, increasing, and substantially too, the price of coal getting. I have endeavoured to arrive at what actual burden has been imposed by mines Acts including 1872 and 1887. It was stated before the Royal Commission that ironmasters in Scotland charged it with between three and four shillings on a ton of pig iron, but this was evidently an exaggeration. Mr. Hewlett in his evidence said that unfortunately every Act of Parliament relating to mining had increased the cost of working, and he estimated the

increased cost of the Act of 1872 at eightpence a ton. I saw the other day a paragraph in our principal English mining paper which stated that the coal-owners of the United Kingdom are finding out that the new Mines Act of 1887 is adding very considerably to the cost of working collieries, and therefore to the cost of producing coal. With the provision of new lamps, ambulance appliances, additional workmen, and additional machines of various kinds needed, it has been computed that at many collieries the cost of producing the coal will be increased threepence a ton. An eminent iron and steel master and colliery proprietor, Earl Granville, in a speech in the House of Lords, put the increased cost by legislation at from one shilling to two shillings per ton of coal. I have decided to put the additional cost of all the Acts and amendments, commencing 1872 and and ending 1887, at one shilling per ton of coal. Sanitary and educational and other legislation, by adding to local rates, has still further increased the cost of coal production. Even the various Acts of Parliament relating to employers' liability have added something. One Lancashire colliery firm has been affected under this latter head alone to the extent of fourteen hundred pounds a year. All this could have been borne, and would have been borne philosophically, but prices went deplorably lower and lower, while expenses were going higher and higher; and there seems to me, for reasons given and others that we shall give, no substantial ground for hoping either that prices will increase or that expenses will decrease.

Something must be done.

During the many centuries in which our great English industries have been built up, our native genius and enterprise and national spirit have always met and overcome difficulties which have arisen. When timber became scarce three hundred years ago we introduced coal; when in the

present generation iron threatened to become obsolete, we introduced new processes, re-modelled our plant, and launched out into the manufacture of steel. A greater difficulty now stares us in the face, and must be swept away as all our previous troubles have been. We want a re-adjustment, fair and equitable, in the arrangements now existing between the parties and interests of mining operations.

Existing Burdens and Suggested Remedies.

Mr. Maskell Peace's Bill for Relief of Mineral Tenants.

When proposals are made, as they have been and are being made, to interfere with mine rents, objection is taken, and perhaps not at all unnaturally, that there ought not to be interference with contracts duly entered into, and that each party should abide by undertakings made for better or worse. To this it may be said that the very existence of nations implies that there shall be a power competent to make any and all needful arrangements in the interests of the common weal. The present generation is getting quite accustomed to such State interference. We have seen in our day the abolition of purchase in the army, and the abolition of the truck system, the passing of the Hares and Rabbits Bill, giving to the tenant whatever agreement he may have entered into with his landlord an absolute property in the ground game on the land which he rents; the passing of measures dealing with employers' liability, which in their latest phase as emanating from a Select Committee of the House of Commons makes compensation to workmen compulsory, no matter what contracts an employer may make with his employés; the establishment of a Railway Commission, with powers to modify railway charges; and, most important of all, a Land Commission, which has very recently made a wholesale reduction in agricultural rents.

And those who advocate interference in mining leases contend that mining operations have a special claim. In a "Bill for the Relief of Mineral Tenants," prepared by my distinguished friend, Mr. Maskell William Peace, a copy of which he has kindly placed at my disposal, and whose very high authority upon matters affecting mining will be readily admitted alike by miners and colliery proprietors and mine owners, he gives reasons for interference with existing contracts, so much better than I can advance, that I quote them here. Mr. Peace says, with respect to the special grievance of mineral tenants, which he proposed to redress by his Bill, "It should be borne in mind what the late Lord Chancellor Cairns said of mining leases:—'But without pursuing the question with respect to agricultural leases further, I should doubt extremely whether dicta of this kind apply at all to the leases of mining subjects; for although we speak of a mineral lease, or a lease of mines, the contract is not in reality a lease at all in the sense in which we speak of an agricultural lease. There is no fruit—that is to say, there is no increase, there is no sowing or reaping in the ordinary sense of the term, and there are no periodical harvests. What we call a mineral lease is really, when properly considered, a sale out and out of a portion of the land. It is liberty given to a particular individual, for a specific length of time, to go into and under the land, and to get certain things there if he can find them, and to take them away just as if he had bought so much of the soil. It is very difficult to apply to a case of this kind dicta which evidently relate to the ordinary process of agriculture." Mr. Peace proceeds to show that "it has been found politic from time to time to mitigate the stringency of leases in favour of the tenant. The power of re-entry for non-payment of rent was relieved by statute, so that upon a payment of the rent the re-entry clause

should not operate; and several Acts were passed which mitigated the power of re-entry on the part of the landlord for all breaches of the lease, except assignment without consent, and enabled the Chancery Division of the High Court of Justice to assess damages for breach of contract in lieu of re-entry." Mr. Peace's bill was to provide against loss of the enormous sums known as overpaid mine rents, and he furnishes some very cogent reasons for relief. "The coal which has not been got is not left through any fault of the lessee, but in consequence of a long period of depression following upon a comparatively short period of inflation. A condition of things has arisen with which mine tenants are unable to cope, which no forethought could have anticipated, and which no energy could counteract. The market is unable to receive the number of tons which the tenants have bound themselves to pay for during the terms of their leases. At the time that a very large number of the existing mineral leases were made, it was evidently anticipated both by landlords and tenants that the prosperous state of things then existing would continue. This, as is only too well known, has not been the case, and only by an alteration of the law can an adjustment be made. Many landlords could grant relief but will not, others acting as trustees plead inability." [I had a letter a few days ago from a mining engineer, saying that the great difficulty in working an important mine with which he was connected arose from the entail preventing the tenants for life giving permission to interfere with the surface at certain places, necessitating the workings been driven in enormous distances. In this particular case the acting landlord would remedy the evil, but the law will not allow him.] Mr. Peace continues:—"The result of the existing condition of things, so different from what was anticipated when leases were made, is, that on taking coal on which very large

sums of money as certain rent have to be paid to the landlords annually, the tenant, while seeking to recoup himself for this payment, will pull every ton of mineral he can out of the mine, and if his royalty is leased from several landlords, he may also be tempted to work the mineral with a view to his payment rather than in a workmanlike manner and in the safest way. The result is, the market gets overstocked and glutted with over-production, no profits are realised by the tenants, and low wages are paid to the miner." Mr. Peace adds that "the total amounts of overpaid certain rents in respect of coals leased in England is estimated at many thousands of pounds." We may venture to say that the actual amount now standing as overpaid mine rents is certainly hundreds of thousands and it may be even millions of pounds, much of which we fear is lost beyond recall. A good deal, we venture to hope, will not be lost. Mr. Peace's bill deals only with these overpaid mine rents, and the Court of Chancery under his proposals was to be empowered to extend the term for a further period not exceeding one-third of the original term, and of course during this extended term no rent would be claimable on coal already paid for. Whatever can be said as to other suggestions that may be made in this paper, there ought to be no difference of opinion as to the necessity for this very just and mild reform. A royalty receiver has no more moral right to coal which he has been paid for, than a man has to keep a house, or a horse, or a waggon of coals, or a farm, or shares in a concern, for which payment has been made. And yet I suppose that under the existing law a colliery firm may pay hundreds of thousands of pounds for coals which by causes beyond their control they cannot work during the term of their lease, and that same coal can be leased again and paid for again, although as Lord Chancellor Cairns judiciously and forcibly puts it, that coal has already

been sold out and out. I wish to use no heedlessly strong language, but such a condition of things clashes with the general idea of fairness and justice.

Suggested Remedies.—Mr. W. Y. Craig's Chamber of Commerce Resolutions.

Another very distinguished friend of mine, Mr. W. Y. Craig, formerly M.P. for the undivided division of North Staffordshire, and with large experience of mining, has gone very much into the question with which we are now dealing and under his guidance the North Staffordshire Chamber of Commerce framed certain resolutions calling for an alteration of the law, and the annual meeting of the Associated Chambers of Commerce of the United Kingdom ratified their resolutions; therefore they come to us with very high recommendations. In a communication with which Mr. Craig has favoured me, he says the resolutions did not reach all that he could have desired, "but their adoption into law would establish a just and righteous principle of leasing in place of that at present existing, which, in plain language, is moral fraud. As matters now are, a lessor has power to bargain for capital and skill to be applied to his property in search of mines, and to work mines, the lessee having to pay a fixed rent for what is, it may be undiscovered, and which can only be won and worked at the cost of that lessee. He (the lessee) is further bound to pay a royalty, out of which the fixed rent may be liquidated if sufficient, but if short, such fixed rent remains the property of the lessor. His (the lessee's) best advisers may have estimated what his capital expenditure would amount to, but as all such calculations necessarily rest on speculative grounds, it may, and frequently does, happen that an expenditure estimated at say £100,000, becomes twice or thrice this amount before the mine becomes remunerative. The lessor may, if he desires, raise on mortgage £50,000 for his own uses on the improvement

of his property, but the man who made it—the lessee—cannot raise a penny without written consent, which is generally withheld. Should the lessee be driven into bankruptcy owing to the exhaustion of his means and his inability to borrow on the security of his lease, the lessor can re-enter and take possession of all at breaking up value, which, in the case of £150,000, might probably be about £10,000. Mr. Craig's resolutions provide that mining lessees shall have the right to assign, sell, or under-let their property and rights in the mines leased to them, subject to their remaining responsible to the lessor; further, that on lessors exercising their right of re-entry and forfeiture during the term of any lease, they should compensate their lessees for the amount of capital invested by them on the mines according to their market value, and that lessees shall have the option of requiring mine rents and royalties to be adjusted on a fair basis according to the fluctuation of the market, and that there should be established in every mining district a mining tribunal, empowered to deal with the matters referred to by the resolutions, and that such court should consist of one legal assessor and two mining assessors. It will be seen that Mr. Craig's resolutions, which commended themselves to not only the mining community of his own district, but to the Associated Chamber of Commerce representing the trade of the United Kingdom, are more far reaching than Mr. Peace's extremely moderate bill, but the principle of relief to mineral tenants underlies them both. Mr. Craig in his communication to myself, argues that "his resolutions should become law, and are demanded on the grounds that the contracts between lessors and lessees are immoral, inasmuch as they affect the interests of third parties, namely, the workmen have less wages, as the capital must be redeemed within a short period owing to the risk of its falling into the lessor's hands by virtue, or, to speak more

plainly, by vice of the lease; the workmen and the general public are often ruined by the sudden stoppage of work owing to the re-entry of lessors. In one case a colliery employing 1,000 men was stopped for two years, and in another case a colliery employing 1,500 men was stopped and has not since resumed work, practically ruining thousands of a population. The re-entry in both cases was in consequence of inability to pay rent, and three years back rent cancelled the lessor's obligations to pay anything, that is the lessors claimed everything in lieu of three years' mine rent. The lessees lost all. Mr. Craig's especial points are that any lessor on re-entry should be liable to pay full market value, and that mine rent should be by sliding scale, placing lessor and lessee on the same footing as to good times and bad times. This regulation did not touch the question as to the amount of royalty per ton; his wish was to establish a righteous principle and the amount of royalty would regulate itself.

Debate on Mine Rents in the House of Commons.

In the month of April, 1886, a discussion upon mine rents was raised in Parliament, but so far as I can gather from the records it was taken at a somewhat unfortunate time, and did not arouse much attention. It was argued then, and I think fairly enough, that the much spoken of freedom of contract did not apply in this case, because minerals were practically a monopoly, and landlords were masters of the situation, and Parliament had always claimed, and latterly were exercising a very free hand in dealing with monopolies, as in the case of railways and land. It was incidentally mentioned during this discussion that the old system of mine rents was entirely different from the present high paid rents and high amounts per ton. The landlord then received a certain proportion of the output; if much was raised his share was proportionate; if none was raised he (the landlord) received nothing. The

discussion was upon a resolution to the effect that the existing system of contracting for mining rents and royalties was unsatisfactory, and should be amended by the Legislature on an equitable basis in the interests of all concerned. Such a resolution no doubt comes under the head of abstract resolutions, of which there are so many in the House of Commons every session; but very many persons engaged in mining sympathised with its spirit. The mover of the resolution repudiated the idea that they who were associated with him were mere agitators, desirous that the State should relieve them from the responsibility of bad bargains. He would not lift his finger to give such relief. What they were striving for was the relief, not of individuals, but of national industries.

DEPUTATION TO THE HOME SECRETARY ON MINE RENTS.

In the month of March, in the same year, 1886, a very influential and entirely non-partisan deputation of members of Parliament and others waited upon the Home Secretary on the same question. In making mention of Cornwall, a county which has been very much hampered by harassing mining leases, it appeared that mine landlords there possessed and exercised powers as absolute as those of Feudal times. Leases are granted usually for 21 years. There are heavy fixed rents and dues on the output, paid in very many cases, not from profits, but from actual calls on shareholders, the mines themselves being worked at a loss. Enormous charges are made for surface damage to land, as much as £100 per acre for land whose annual value is £1. At the expiration of the lease the entire plant becomes the property of the landlord. And even when a mine is "shut down" the owners are bound to offer the whole concern, plant and all to the landlord at a valuation. If he refuses to purchase the plant, and he invariably does refuse, the owners can sell the plant.

But all stone built erections and the pit shaft and workings are the property of the landlord. The tenant gets nothing for "unexhausted improvements" which his money has made. Mention was made by the deputation, of the Coal Measures in the Forest of Dean, which are worked at very low profits and very considerable expense, and on which it appears that the Crown had originally a title to a proportion of the profits. The separate quantities let in the Forest of Dean would seem not to be extensive and are known as "Gales." A re-valuation takes place each 21 years, and about 23 years ago an arrangement was made under which the Crown received twopence a ton royalty, one penny a ton way-leave, and £6 a year rent. The average profit at the end of the term was shown to have been twopence per ton for the 21 years, and the Crown ought to have received one penny a ton; what the Crown did receive we have mentioned. The re-valuation two years ago stipulated that from that time the Crown should receive threepence a ton royalty, one penny a ton way-leave, and £30 a year rent.

Mine Rents in the United Kingdom.

Coal Royalties in the Forest of Dean.

I have had an opportunity of consulting, thanks to the courtesy of your President, the printed "Award as to the Coal and Iron Mines in Dean Forest," as made by a Royal Commission which made an inquiry in the years 1838-41. It would appear that well nigh from time immemorial the mines of the Forest of Dean have been worked by the free miners, who were male persons born within the district and had worked one year and one day in a mine. These free miners, of whom at the time of the Commission there were 829, enjoyed the right of working the mines under a licence from the Crown, to whom a nominal payment was made amounting to what seems to have been one-fifth of the profits. The system of operation was regulated by a court or jury of free miners,

and documents of their deliberations are now in existence, dating back 220 years. It cannot be said that the free mining arrangement worked well. There was frequent and expensive litigation. The spoliation and destruction of each others coal was of frequent occurrence. The powers of the free miners' jury were altogether inadequate. The whole spirit of the proceedings was inapplicable to the deep coal. To remedy the confusion a Royal Commission was appointed to determine in whom the right to work certain mines was invested, and to fix future payments. This Commission, comprising Mr. Buddle, Mr. Sopwith, and Mr. Probyn, made all needful inquiry and signed their award in 1841. Under this award the rights to work were confirmed. Royalties varying from one penny to twopence per ton on coal, and varying from twopence to fourpence per ton on ironstone, were fixed; and in every separate case a certain rent which must be paid if no coal or ironstone was worked. As regards the coal mines, two years were allowed in which to open out the mine, during which period no royalty and no rent should be payable, and no royalty should be payable on coals consumed by any colliery engines or for other necessary colliery purposes. As regards iron mines, a period of four years was to be allowed for opening out the mine, during which time royalty should not be payable. The certain rents on iron mines varied from £2 per year to £40; and the certain rents on coal mines varied from £1 per year to £250. For the purpose of making this paper as complete as possible, I endeavoured to obtain information from many sources, offering, where privacy was desirable, to mention neither names of persons nor places. My efforts resulted in a mass of matter, I can hardly say a mass of information, a good deal being mere assertion, unsupported by facts and figures. Still, some reliable data have been obtained, and probably sufficient for the purpose.

Coal Royalties in Lancashire.

What I wish to do is to show, in addition to what we have already shown, what mine rents and mineral royalties are now, and, to some extent, what they have been. First, we will take our own county palatine of Lancashire. It is generally accepted that a fair average coal royalty will be about sixpence per ton. Mr. Alfred Hewlett mentions that amount in his evidence before the Commission on the Depression of Trade, and no man, living or dead, has had more to do with Lancashire mining leases. Mr. Hewlett does not say how much this sixpence per ton is increased by overpaid mine rents, past and present. In his own case I should think that on an output varying from 1,500,000 to 2,000,000 tons a year, and reckoning overpaid mine rent now being paid, and moderate interest on what has been paid, the actual royalty per ton of coal produced will be very considerably more than sixpence. A colliery proprietor told me a week or two since that every ton of coal he was raising had a royalty burden of one shilling and fourpence. I put the Lancashire average at eightpence.

Coal Royalties in Yorkshire.

An eminent authority in Yorkshire writes me that in that county the coal royalties range from fourpence to ninepence a ton, and that in many cases overpaid mine rents make the amount stand at one shilling and thirteenpence. Another Yorkshire authority tells me that leases granted during the years 1872-73-74-75 were in many instances as high as one shilling per ton ; and that thirty and forty years ago the average royalty would not exceed fourpence. I put the present average royalty on Yorkshire coal at eightpence per ton on the total production.

Coal Royalties in Durham and Northumberland.

In county Durham I find that Mr. J. B. Simpson, as representing the Durham Coal Trade Association before the Royal Commission, and connected with both lessors and lessees, said that the royalties in the Durham coal field were about one-twelfth of the then selling price, or about fivepence per ton, and that there were heavy charges for way leaves and fixed rent. In the county of Northumberland, Mr. G. B. Foster, on behalf of the Northumberland Coal Trade Association, and connected with lessors very largely, put the royalties in his county at from fourpence halfpenny to fivepence halfpenny per ton. Sir C. M. Palmer, M.P., and one of the Royal Commissioners, said he knew one colliery in Northumberland which, on an output of 650,000 tons a year, paid a royalty of tenpence per ton. I shall put the average royalties in Durham and Northumberland at eightpence per ton on all coal raised.

Coal Royalties in the Midlands.

A high authority in Nottinghamshire, and with extensive experience in the coal field, puts the royalty per ton in the Midlands as varying from sixpence to eightpence per ton, and as that district will know something of the blessings of overpaid mine rents which are peculiar to no county, I shall venture to put the average royalty on all coal raised at eightpence per ton.

Coal Royalties in Scotland.

In Scotland there is a very wide range indeed. The royalties are as low as fourpence-halfpenny and as high as one shilling and fourpence. Some forty or fifty years ago coal royalty in Scotland varied from twopence to fourpence-halfpenny. During the high years of 1872-73-74-75 coal was leased at one shilling and eightpence per ton. I shall put the royalties in Scotland on the very moderate average of eightpence per ton of coal raised.

Coal Royalties in Staffordshire.

The Staffordshire coal royalties are given me by Mr. Craig as varying from sixpence to eightpence per ton, not including overpaid rents. I shall also put this as an average of eightpence per ton on all coal produced.

Average Royalty on Coal.

Now the districts I have covered—[the Forest of Dean, which is not comparatively a great coalfield, I have mentioned elsewhere]—namely, Lancashire and Yorkshire, and Durham and Northumberland, and Nottinghamshire, and Scotland, and Staffordshire—[I tried to get information relating to North and South Wales but did not succeed]—represent the very large proportion of all the coal raised in the United Kingdom, and it is perfectly fair to say that on the 160,000,000 tons which we produce each year, we pay on fixed rents and wayleaves and royalty an average of eightpence per ton, which means an annual tax on our coal industry of more than five and a quarter millions sterling. But my desire is to fortify myself as far as possible, and I cannot think my average of eightpence excessive when I turn to evidence given before the Royal Commission on the Depression in Trade, and afterwards published not only in the Parliamentary Blue Books, but by the British Iron Trade Association in a very handy little volume, and find that it stated that the coal royalties of the United Kingdom might be taken at from sixpence to one shilling per ton.

Ironstone Royalties in Staffordshire.

I also endeavoured, in my enquiries, to obtain some information about royalties on ironstone. [The Forest of Dean ironstone royalties have been named.] In Staffordshire the calcined ironstone is given as two shillings per ton.

Ironstone Royalties in Cleveland.

In the Cleveland district an elaborate statement, placed at my disposal by Sir Bernhard Samuelson, M.P., and Mr. John Dennington, the able secretary of the Cleveland Mine Owners' Association, shows that the royalty on Cleveland ironstone leased before 1870 would average fivepence per ton, and that leased during the years leading up to 1874 would average sixpence per ton; but, as Mr. Dennington says, practically all the valuable ironstone in the Cleveland district has been leased previous to 1870. Mr. Dennington, in the very valuable communication which he sent me, shows that in the fourteen years ending 1863 the Cleveland annual ironstone output was 1,250,000 tons; in the nine years ending 1872 the Cleveland annual ironstone output was 3,358,000 tons; and in the fourteen years ending 1886 the Cleveland annual ironstone output was 5,941,991 tons, making a total in thirty-seven years of 130,909,946 tons, for which £3,000,000 was paid in royalty. From this 40,000,000 tons of Cleveland pig iron were made, on which the total amount of royalty paid on the ironstone and the coal (and the limestone reckoned at three halfpence a ton) has been £6,000,000. Mr. Dennington says "the price of pig iron had no parallel years ago with present prices, and royalties that were not felt oppressive then, when iron making was a profitable pursuit, have since been felt to be otherwise. As to the remark, 'You make a bargain, and you must stick to it,' there was no bargain made for the bad times that have been recently experienced. A sliding scale would seem to be the right basis for regulating royalties."

Ironstone Royalties in Lincoln and Northampton.

In the counties of Lincoln and Northampton the ironstone royalties will reach one shilling per ton.

Ironstone Royalties on the West Coast.

The royalties on iron ore on what is termed the West Coast, which will include Lancashire and Cumberland, were given in evidence before the Royal Commission as two shillings and sixpence per ton; and Mr. J. T. Smith made the startling statement that a diminution by one-half of coal and iron ore royalties would relieve the manufacturers of steel rails to the extent of five shillings a ton.

Ironstone Royalties in Scotland.

In Scotland we find an eminent iron-making firm paying two shillings and sixpence per ton for ironstone now, upon which some 40 or 50 years ago the royalty charge was only twopence.

Coal and Iron Royalties for Ten Years.

The average yearly production of ironstone in the United Kingdom during the past ten years has not been less than 16,000,000 tons, which at the very moderate estimate of ninepence per ton on an average considerably exceeds an annual royalty payment of half a million of money. The mining industry has been depressed, that is hardly the word now, we want a stronger one to express the condition of affairs, for ten years, and during that period wages have been far from excessive, colliery proprietors and mine workers profits taking them all round have scarcely been visible, and royalty owners have received upon coal and ironstone and limestone, certainly not less and probably more than £60,000,000, out of which nothing has gone for local rates whilst the other two parties, colliery proprietors and colliery workmen have had to pay all local calls. Mr. John Dennington writes me, that I am right as to coal; the royalties pay no rates. But under the Rating Act of 1874, the ironstone lessees in Cleveland can deduct, and do deduct, from these royalties, one half of all local

rates levied upon mines. Why one law for ironstone royalties and another law for coal?

Royalties on Tin, etc., in Cornwall.

Mr. William Thomas, of Camborne, secretary to the Mining Association and Mining Institute of Cornwall, tells me that mines in that county generally pay "dues" of 1-18th to 1-24th of the produce. Exceptional cases pay 1-15th. In addition a Cornish mine would have to pay £100 an acre for land taken up by work heaps, &c. There are many instances, says Mr. Thomas, in which the landlord during pleasure, reduces "dues" to 1-30th, 1-60th or sometimes gives them up entirely, that would be of course during periods of depression. Recently attempts have been made to introduce a sliding scale, for instance with tin at or below a fixed price 1-30th, and when above that price 1-20th or 1-24th. The leases generally run for 21 years, and although now it is becoming a general custom to renew leases without fines, a heavy fine is sometimes inflicted. Mr. Thomas continues—If the terms of the leases in Cornwall were always enforced they would indeed be burdensome, but the landlords in 19 cases out of 20 are ready and willing to consider any case of hardship on its merits, and the result is that landlord and mine worker can get on fairly well together. The infliction of the enormous fine of £25,000 at Dolcoath created a very great sensation, and such a thing will not easily be endured again in the county. Public opinion was very strong, and the same Dolcoath landlord gave up all dues at other less productive mines.

Salt Rents and Royalties.

Mr. Joseph Dickinson.

I am indebted for the following valuable information as to rents and royalties in the salt districts to the annual mining

report of your president in 1881 :—The rock-salt and brine are each looked upon as real property, and the terms for and mode of leasing are the same as for ordinary mineral property; and in the salt districts they technically call a ton of salt made out of brine, a ton of brine. The ordinary royalty payable for such salt seem to vary from about twopence to sixpence per ton, the price for black rock usually varying about three halfpence under that for best, with a ground rent for land occupied and usually a stipulated minimum rent. For brine the terms also vary according to circumstances. Sometimes the royalty is merged into an annual rent of so much, say £50 per Cheshire acre, for the land occupied for the pits and salt works. For this payment the lessee may sink for, and pump brine for his own use, but for what he sells off the premises a royalty is payable to the lessor of about one penny or twopence per ton of manufactured salt, and the price charged for the brine by the lessee who sells it is from fourpence to sixpence per ton of manufactured salt; and about the same price is charged when the owner of the land is himself at the cost of sinking the shaft, pumping and finding pipes to a certain distance for carrying the brine on the surface. The highest price for brine sold and delivered is said to have been one shilling per ton of salt manufactured from it, with an additional charge per Cheshire acre for the land occupied for the salt works, each being guaranteed to a certain amount by a fixed minimum rent; but this proved to be too high and has been reduced; and the highest royalty now paid by a lessee who sinks and works his own shafts is said to be fourpence-halfpenny per ton of manufactured salt, with an additional stipulation for ground rent. The reservoirs of brine in the inundated old rock salt mines are treated in the same way. These stores are very valuable but only to those who have legal access. No one to whose

land the brine will not flow may pass his boundary to draw from them; an outstroke for this purpose may be arranged for, and in one instance where it is obtained the sum paid for the privilege is stated at twopence per ton of manufactured salt, which, as the firm sank their own shaft, and pump for themselves, is considered equivalent to buying brine at sixpence; that is, by allowing fourpence for sinking and pumping, and twopence royalty. Captain Townsend, in 1881, owned three-fourths of the township of Wincham, and was the lessor of several other properties. Messrs. Parkes and Yeoman paid him yearly for ground rent £25, without having the right to sink for brine, and for brine which the lessor pumps sixpence per ton of manufactured salt. Mr. Child paid ground rent £100, with the right to sink, and for brine twopence-halfpenny per ton of salt. Mr. Bull paid ground rent £271, and for brine supplied sixpence per ton of salt. This tenant has sunk a shaft, and pays twopence-halfpenny a ton up to 20,000 tons, and twopence a ton afterwards. The tenants, where the lessor pumps, pay sixpence, and where they pump for themselves, twopence halfpenny. The terms of Lord Stanley of Alderley, at Anderton, were originally—land, £50 per annum, brine rent for making common salt and fine stove salt, one shilling and sixpence per ton. From 1850 to 1860 many of the works at Anderton remained idle. The rents have now been reduced. At Winsford, in 1881 and from 1855 the brine had been pumped at various rates, from fourpence to sixpence per ton of salt produced. Prices for the privilege of pumping brine have had to come down in consequence of competition with other districts. In one of Lord Stanley of Alderley's leases of 40 years ago, threepence per ton more was paid than in 1881. As these high leases expired, reduction in rent was solicited, but the lessor refused, and several works remained idle. When threepence a ton was taken off work was

resumed. One tenant had occupied under Lord Mansfield for twenty-five years, and during that period had three leases, each one at an increase upon its predecessors. At Northwich the royalty upon white salt varies from fourpence to ninepence, and about sixpence at Winsford. Lord Delamere held as lessor all the salt works on the west side of the River Weaver, from Newbridge to Winsford Bridge. All his tenants were brine pumpers, the lessor having let the right of brine pumping to them. The rental from brine pumping is charged upon the land in the general lease, the lessor having no specific royalty; the lessees merely pay so much a year. Land well situated in the neighbourhood of Winsford, where there is access both by river and railway, would let for about £40 per Cheshire acre for salt works. Rents and royalties payable for and in consideration of brine were in existence in the time of William the Conqueror, and the last of the Saxon Kings, with curious customs and regulations, as shown in "Domesday Book." The King had two-thirds and the Earl one-third of the tolls, in which manner it continued till the time of Hugh Lupus, Earl of Chester. The Earl's salt pit at Nantwich was toll free, but the produce was limited to the purposes of his own household. If he sold any, account was to be made to the king for two-thirds of the toll. At Middlewich, a man from another hundred gave twopence for a horse-load, but a man from the same hundred gave only a halfpenny for a horse-load. At Northwich, persons from other shires were charged double for a cartload. At Nantwich for tolls withheld, forfeitures were imposed, the freemen having to pay ten times as much as those who were not freemen. How all these ancient rights of the Crown passed away does not appear to be known. Perhaps disposed of; perhaps not considered worth collecting. They are now possessed by the freeholder.

SALT RENTS AND ROYALTIES. Mr. THOMAS WARD.

I have been favoured with some valuable information by Mr. Thomas Ward, of Northwich, a very high authority in the salt trade. He says that in 1828 there were various methods of estimating salt royalties. In one set of salt works the brine consumed was charged at £30 per annum for every 600 feet of evaporating area in the pans. In another set of works £15 per annum for every 600 feet of pan area, and sixpence per ton on common salt made, one shilling per ton on fishery or rough salt. In another, having an area of 3a. 3r. 8p., there was a surface rent of £37 per annum and 6d. per ton on common salt, and one shilling per ton on fishery. Again, an area of 18a. 1r. 35p. the yearly rent was £244 and no royalty. In all these cases the parties sank their own shafts and pumped the brine at their own expense. Again in rock salt, a mine and field of 4a. 2r. 11p. paid £62 per annum; tenants sinking shaft and finding their own machinery. A mine and fields overlying, having an area of 8a. 2r. 36p. had a rental of £200 per annum and sixpence per ton on export rock salt, and threepence per ton on black or cistern rock. Another mine and fields, area 5a. 3r. 39p., rental £150 and sixpence per ton export rock, and threepence black rock. In 1852 a lease of 7a. 3r. was made at £150 per annum, and fourpence per ton of rock salt got; later on £220 per annum for rock salt and brine and surface for works. Land for brine shaft, 2a., rent £60 per anuum, tenant to sink shaft and pump brine. Mine and land for salt works, 6a., surface, right to get rock salt and pump brine over about 130a., rent £370 per annum, and threepence per ton on all additional salt raised or made over 80,000 tons per annum. A very recent lease, on very favourable terms, is based upon a moderate surface rental, and a royalty of twopence per ton on all rock salt over 8,000 tons per

annum, or fourpence per ton on all white salt over 12,000 tons, the landlord pumping brine. These terms are exceptional and peculiar. In another recent lease the tenant pays fivepence per ton for brine, the landlord pumping it. Rock salt royalties are low, say threepence on the average. An agreement for salt and chemical works of present year, gives a surface rent of £5 per statute acre of surface, a royalty of threepence per thousand gallons of brine, roughly called a ton of salt, and threepence per ton on rock salt.

Lead Royalties.

I am indebted to an eminent mining authority for information as to royalties in the North of England on lead. It would seem that previous to 1882 the mine rents and mineral royalties were on a similar basis to that which still exists as regards coal, namely, fixed minimum rents and royalties per ton, independent of selling prices. In 1882 proposals were made to introduce a sliding scale fluctuating according to market value. The proposed scale was as follows:—When the price of the lead ore is at and above £15 per ton, the royalty to be 1-9th or 1-10th; between £14 and £13, 1-12th or 1-15th; between £13 and £12, 1-15th or 1-18th; between £12 and £11, 1-18th or 1-20th; between £11 and £10, 1-20th or 1-25th; at and below £10, 1-24th or 1-30th; or, all round, whatever the price, 1-18th or 1-20th. And now all the principal lead royalties in the north are regulated by a sliding scale in relation to the price of pig lead. The following are two sliding scales of royalty upon lead ore in the North of England, based upon the selling price of pig lead:—

A.

Price of Pig Lead.	Royalty.
Above £20 per ton	1-10th.
Between £17 and £20	1-11th.
„ £14 and £17	1-12th.
„ £13 and £14	1-13th.
„ £12 and £13	1-14th.
„ £11 and £12	1-15th.
„ £10 and £11	1-16th.
At and below £10	1-18th.

B.

Price of Pig Lead.	Royalty.
Above £21½ per ton	1-7th to 1-10th.
Between £20 and £21½	1-8th to 1-11th.
„ £18½ and £20	1-9th to 1-12th.
„ £17 and £18½	1-10th to 1-13th.
„ £15½ and £17	1-11th to 1-14th.
„ £14 and £15½	1-12th to 1-15th.
Under £14	1-13th to 1-16th.

The two proportionate amounts of royalty as shown upon the latter scale are respectively above and below free drainage. Perhaps a word or two of explanation is needed as to these terms, above free drainage and below free drainage. Lead mining is generally in mountainous districts, and adit levels are driven in from the sides of the valleys to the lead veins. These adit levels drain the water above, and answer as haulage roads for the output. When mines have to be worked deeper than the level of the valleys, shafts have to be sunk below water level and the water has to be pumped, hence the terms above and below free drainage. When the water is drained by gravitation and the haulage accomplished by levels, the costs of mining are less than when water has to be pumped and the mineral produce raised up shafts, and the difference in the scales of royalty is partly to compensate for the extra cost. It is an equitable arrangement by which

the lessor can induce the lessee to work the deeper mines, which otherwise the low price of lead would not allow the lessee to do with the extra attendant cost. It has been found good policy for the lessor to give this premium upon deeper mining. I am informed that the lead mines of the North of England are all held by the lords of the manor, who generally, but not in all cases, hold the surface lands as well. I am further informed that there are in some cases, but not in all, fixed minimum rents, mergeable into the tonnage royalties, but this is the exception and not the rule. I assume from this that the rule is tonnage royalty only, either by sliding scale or a fixed amount per ton.

The Royal Commissions and Mine Royalties.

Royal Commissions appointed by Parliament generally are disappointing. We expect too much, and we get too little. The last Royal Commission did report that our mine rents and mineral royalties formed a minor cause of trade depression. The next Royal Commission will report very much more strongly.

Mine Rents in other Countries.

I wish now to show on the authority of the Royal Commission on the Depression in Trade, how mineral royalties oppress English iron and steel makers, and other great users of minerals, and do not oppress those with whom we have an ever increasing competition. In Germany, which in many industries has been of late years a very keen and too often a successful competitor, the ownership of coal is vested in the State, and also the iron ore. The royalty upon coal is fixed at two per cent. on the profits of the undertaking, and on iron ore there is no royalty at all. No objection on the part of the owner of the soil is allowed to prevent the minerals on his property being worked, such prohibition being considered as inconsistent with the interests of the nation. In France, which owing to some peculiarity in the climate, seems

to be able to manufacture coke in a manner and to a profit which although tried, has been found unprofitable in England, all coal and all ironstone belong to the State. The fixed rents are indeed nominal, amounting to one halfpenny an acre, and the royalty is based upon five per cent. of the profits. Suppose we in England make two shillings a ton profit upon our coal, a sum which would represent £16,000,000 sterling a year, and a percentage upon capital which would remind us of the good times which come again no more, or even supposing we made no profit at all our royalty charges would average eightpence a ton. But if a German colliery proprietor realises two shillings a ton profit his royalty would be about one halfpenny a ton, and his French rival would have a charge of one penny farthing. If neither of them made any profits neither of them would pay any royalty at all. In Belgium all the coal belongs to the State, and, in addition to a very nominal fixed rent, the royalty is two and a half per cent. on the profits. Ironstone there practically is none in Belgium, at any rate scarcely any is worked. The minerals in Spain also belong to the State, and are leased on nominal terms. I shall no doubt hear it said that whether minerals belong to the State or to private owners the system of basing on profits is wrong, and although we have seen that the arrangement is not confined to the Continent of Europe, but prevailed in England also, I quite agree that the system is not a good one, although I gather from the reports of meetings of mining companies in Cornwall it is finding a good deal of favour there. Good management may realise profit in working when bad management will realise loss, and in my opinion, whatever may be the futute of mining and mineral royalties these latter should not depend on profits. But the non-introduction of just remedies naturally tends to the encouragement of proposals that are not just.

Comparative Effects of Mineral Royalties at Home and Abroad.

But let us see how the mineral royalties of England affect us in competition in manufactures. In England mineral royalties affect pig-iron on an average four shillings and sixpence a ton, plates for shipbuilding five shillings and ninepence a ton, and steel rails five shillings and sixpence a ton. In France the mineral royalties are on pig-iron eightpence a ton, on plates for shipbuilding one shilling and three halfpence a ton, and on steel rails elevenpence a ton. In Germany the mineral royalties are on pig-iron sixpence a ton, on plates for shipbuilding one shilling a ton, and on steel rails eightpence halfpenny a ton. So that under this head of mineral royalties England has burdens of four shillings and fourpence per ton on pig-iron, four shillings and ninepence per ton on plates for shipbuilding, and four shillings and ninepence per ton on steel rails, of which our German competitors know nothing, and four shillings and twopence per ton on pig-iron, and four shillings and sevenpence per ton on plates for shipbuilding, and four shillings and sevenpence per ton on steel rails, of which our French rivals know nothing; and we have to compete with these nations in the markets of the world. I am well aware that in England we have some very great natural advantages, that our seams of coal and other minerals are valuable in themselves, and lie conveniently to our great industrial centres, and from our limited area lie close, comparatively, to the sea board; also that our workmen, man for man, will probably raise more minerals than in the countries abroad, and that we have the best appliances and the most skilled management. That makes my argument all the stronger. We nearly do hold our own against the world as it is. We could, by the removal of artificial drawbacks, beat any and every one of our competitors.

Sir Isaac Lowthian Bell on Mineral Royalties.

Sir Isaac Lowthian Bell's remarks after and upon this comparison are at once so strong and so fair, and express so much better than I can do, and with so much more force, that I quote him. He was speaking or writing not quite two years ago, and matters industrially are not better now than then. "In the present depressed state of the iron trade in the United Kingdom, while ironworkers and mine owners are working at a rate which gives practically no profit to the capital employed, and in many cases results in a loss, it is widely felt as a grievance that landlords to whom royalties are payable receive full amount reserved by the leases. It is contended that, should the present low prices continue, those engaged in mining in this country must be reduced to bankruptcy, and a great industry must be extinguished unless the royalty receivers are willing to abate something of their legal rights, which now give them very nearly ten per cent. of the manufactured article." Mr. Craig puts the charges on Staffordshire pig-iron at fifteen per cent. of the selling price. Mr. J. B. Simpson, of the Durham Coal Trade Association, said that in Durham, without making any allowance for way-leaves or over-paid rents, the royalty on coal was one-twelfth of the selling price. Mr. Alfred Hewlett said that in Lancashire the coal royalties amounted to ten per cent. of the selling price. Sir Isaac Lowthian Bell continues:—"Royalties in minerals resemble in the relation to the cost of production and the price paid by the consumer the rent paid by agricultural land. That is to say a royalty will only be payable when the demand for minerals exceeds the supply which can be procured in the easiest and cheapest manner, and the theoretic royalty will be the difference in cost between the cost of production and placing in the common market of the more favourably situated mine, and that which is most expensive to work, and yet can

be worked at a profit. But in practice most lessees of mine are in the enjoyment of a beneficial lease, not at a rack rent, for mining leases are necessarily usually for a longer period than agricultural tenancies, owing to the need of the lessee for security of tenure on account of the large amount of the fixed capital required in opening up a new mine. Thus as a new mining district is opened up, the more remote or poorer deposit in a growing trade will be leased possibly at as high a royalty as the richer or more accessible mines, which were leased when the prospects of the district were less assured. But even now the owners of minerals in the less favourably situated mines are forced in a losing trade to make concessions to their lessees, though they are able if they hold out for their full legal rights to see all the capital of the tenant made valueless before the loss begins to fall upon them with regard to their royalty. The subject has been receiving a good deal of attention and the injustice has been remarked on, of the workmen having their wages reduced, and the railway companies having their fares lowered, and the colliery proprietors receiving no return on their capital, while the royalty owners remain unaffected during the long continued depression. The remedy recommended in some quarters has been a drastic one, namely, confiscation of landlords rights. "I have not," says Sir Isaac Lothian Bell, "in my experience met a single lessee who disassociates the right of his landlord to the minerals any more than he would question his title to the surface. As is known, when the profits were very high, the landlords had to be content with the same rents that they received under a very different condition of things. It has, however, to be remarked that the present royalties were arrived at by previous experience of the value of the produce of the mine, and there is no reason to doubt that if the present prices of iron had been contemplated as possible when the leases wer

entered into, some provision would have been made for such a contingency. It would seem, therefore, open for consideration whether by means of a sliding scale, the payments of the landlord should not be dependent on the market value of the mineral, a system which in some cases has already been adopted." Such was the reasoning of Sir Isaac Lowthian Bell, who spoke with an unsurpassed authority as a colliery proprietor and an iron and steel maker, who probably knows more of these industries all over the world than any other man, and who certainly has no tinge of the doctrine of confiscation, and his reasoning of two years ago has equal and possibly increased force now. The sliding scale proposal, to vary with market value, is finding much favour all over the United Kingdom, and is certainly a much fairer arrangement than a percentage of profit. There is good reason to believe that most of the ancient leases of coal either gave the lessor a moderate fixed rent, and the lessee could get as much as he pleased without any tonnage, or else the lessor was entitled to a certain fraction of the output. A Scotch correspondent informs me that the very old leases of the Duke of Portland were on these latter lines, and a Lancashire friend suggests that probably the tithe arrangement of one tenth of the market value prevailed.

Conclusion.

The Duty of Royalty Receivers.

The somewhat onerous, and I fear somewhat too difficult a duty which I have undertaken is about completed, and I have endeavoured, however inefficiently and insufficiently, to discharge it fairly. I do not represent either royalty owners, or colliery proprietors, or workers in England's industries; I am simply here as a citizen interested, as all citizens should be, in the welfare of the nation; and I have gladly availed myself of assistance and information from any

reliable quarter. To all who have helped me I tender my sincere thanks. I contend that the amount of mineral rent paid per ton in the United Kingdom is too high and must be reduced. The certain rents which were fixed when prices were higher and expenses lower, are also too high, and must be reduced and provision made whereby amounts already overpaid can be recouped. Many colliery lessees are responsible for certain rents, work or play, representing more coal than they can possibly raise, and more than they could sell if they did raise it. Allowances are not made for physical difficulties of which nothing could be known when the leases were taken and the pits sunk. One eminently well-managed firm pays over £50,000 a year for dead work in crossing faults which, could they have been anticipated, the leases would never have been taken by anybody. A comparatively small colliery has at present to face an expenditure of £1,300 to get at coal, and rent will go on while this £1,300 is being spent although no coal will be got. Surely during the period of such expensive and unforeseen operations rent should be suspended. A colliery firm in Scotland expended £50,000 in opening out a mine, and found that remunerative work was impossible, and relief being refused the mine ceased work. An important concern of more than 50 years' standing and excellent repute, could not contend with existing leases and has gone into voluntary liquidation. How many others may soon have to follow? I have endeavoured to show how vitally important the mining industry is to England, and that it is crippled and cripples kindred industries on which not only our prosperity but wellnigh our existence as an industrial nation depends. The expenses of mineral production have increased to a degree which could not have been foreseen; and these expenses will not only not diminish, but in all probability increase. Every Act of Parliament

relating to mines adds to the cost of production. Will any man say that we have seen the end of Parliamentary legislation affecting mines? Competition in many lands has reduced prices to an extent which any man to have predicted twenty years ago would have been considered mad, and that increasing competition makes any substantial improvement in prices impossible. Does any one dispute the increasing competition? In 1860 America did not make 1,000,000 tons of pig iron. Last year that great off-shoot of England made nearly 7,000,000 tons, being an increase of seven hundred per cent. Twenty years ago America made 2,550 tons of steel rails. Last year the production was 2¼ million tons, leading even England by a long way. In the matter of steel manufacture by our own English basic process, England made in two years combined 623,092 tons. Germany in the same period made 1,986,395 tons. Whilst preparing this paper an ironmaster informed me that even in the manufacture of products to be used in steel manufacture, which for some years has been carried on in England with some success, our German competitors have stepped in and are playing havoc with our trade. Wages in England cannot go much lower. Profits have well nigh vanished, and bankruptcy is within measurable distance. The paralysis of our mining and iron and steel industries would be a terrible calamity to England. Relief must come from the quarter which has experienced nothing of the effects of our unparalleled depression, namely, in an abatement of the conditions of mining leases and the amounts of mineral royalties. Public opinion is ripe. I have letters from members of Parliament who are determined to take action during the present session, and already bills have been prepared by Mr. Maskell Peace, Mr. Acland, M.P., and Mr. Conybeare, M.P. Mr. Burt, M.P., has given notice of a resolution. I shall be told, and have been told, that as a

matter of fact royalty owners do now make a reduction, but that deduction is simply an isolated and temporary concession during the good pleasure of the lessor, and gives the lessee no security for his capital and little hope for the future. Firms with hundreds of thousands of pounds invested want something more substantial in the way of security than mere expectation of temporary relief by a well-intentioned landlord. To make an allowance at will this half-year or next half-year is a hand-to-mouth method of dealing with a very serious question which demands most drastic treatment. I press the matter home to the royalty owners, because they have revelled in the luxury of a settled income, settled in happier times, with pleasant reminiscences and hopeful prospects, while those who have borne the heat and burden of the day, the toilers and the spinners of the mining and kindred communities, have given their time and their money, their genius, and even their lives, contending with a condition of things which they did not make and could not prevent, and hoping on for a better time which has not arrived. Hope deferred maketh the heart sick; depression hopelessly prolonged has driven the ablest and sturdiest of English citizens into a condition well nigh of despair. There remains one promised land to which they look, and I earnestly trust that they will not look in vain. We have had not only in England, but in other lands, cases where moderate relief has been too long postponed, and more drastic relief has been enforced. The best safeguard against revolution is reform, and the strongest preventive against the doctrine of confiscation is wise concession. I ask the royalty owners of the United Kingdom, in the interests of the mining and iron and steel industries, and of the nation, and of themselves, to be wise, and, above all, remembering the progressive and democratic age in which we live, to be wise in time—there is danger in delay.

APPENDIX.

COAL ROYALTIES IN THE OLDHAM DISTRICT.

Kindly furnished to Mr. Dickinson, the President, by Wm. Blackburne, Esq., Civil and Mining Engineer, Oldham, with reference to Mr. Percy's Paper.

During the past 50 years I am of opinion from the most reliable information which I have personally been enabled to obtain, that the actual royalty or rent paid to the landlords for the most valuable and important seams of coal worked at the separate collieries in this district have not been reduced in amount to any considerable extent until the last 10 years. The seams of coal to which I now particularly refer are as follow, viz. :—The Black Mine, the Royley Mine, the Mountain Mine, the Moston Mine, the Great Mine, the Little Mine, the Higher Bent Mine, and the Lower Bent Mine.

The Black Mine has been worked at the following collieries, viz :—The Lowside Colliery, the Glodwick Colliery, the Chamber Colliery, the Oak Colliery, the Denton Lane Colliery, the Ferney Field Colliery.

The average thickness of the mine at Lowside Colliery and Glodwick Colliery was four feet. The average thickness at the other before mentioned collieries was three feet six inches to three feet nine inches. The royalty paid at Lowside Colliery was £450 a statute acre, or an average of 1s. 6d. per ton. The royalty paid at Glodwick Colliery was £400 a statute acre, or an average of 1s. 4d. per ton. The royalty or rent paid at the other mentioned collieries was on a proportion of the selling price per ton at the pit mouth. This mine is of first-class quality, and generally produces a large proportion of house fire coal; a considerable quantity

was forwarded as far as Manchester for sale, and the good quality of the mine was admitted throughout most parts of Lancashire; but at the present time this coal is only being worked at Denton Lane Colliery, and the entire field in this district is well nigh exhausted.

In addition to the above-stated royalty at Lowside Colliery, a landage or way-leave charge was paid to the landlord of the estate on which the pits were situated, amounting to £15 for each and every statute acre gotten from under the adjoining estates.

The Great Mine.

This mine was worked at Lowside Colliery and Glodwick Colliery, and the average thickness was about seven feet nine inches, and the price paid for royalty at Lowside Colliery was £325 per statute acre, or say about sixpence per ton.

The royalty paid for the same mine worked at Glodwick Colliery was £300 per statute acre. The quality of this mine was, to a great extent, very inferior, but about eighteen or twenty inches was equal to Black Mine, and oftentimes mixed and sold with the latter named mine at Lowside Colliery.

Royley Mine.

This mine has been very generally worked in the district at the following collieries, viz.:—the Oak Colliery, the Chamber Colliery, the Stockfield Colliery, the Hartford Colliery, the Hunt Clough Colliery, the Robin Hill Colliery, the Hanging Chadder Colliery, the Royton Park Colliery, the Low Crompton Colliery, the Bent Grange Colliery, and several others.

The average thickness of this mine is from two feet eight inches to two feet ten inches, and the royalty paid at Hartford Colliery, Robin Hill Colliery, and Bent Grange Colliery was about £175 per statute acre, or an average of

10d. to 10½d. per ton. The royalty paid in several of the out-townships, namely, Royton and Crompton, was at a reduced rate in most instances.

This mine is a good, useful steam coal, and very serviceable in the opinion of local cotton spinners.

The Bent Mines.

The Higher and Lower Bent Mines have been, or are being, worked at the following collieries:—The Lowside Colliery, the Oak Colliery, the Ferney Field Colliery, the Honeywell Lane Colliery, the Hunt Clough Colliery, the Denton Lane Colliery, and others.

The royalty actually paid at Lowside Colliery for these mines was under the first lease £162 10s. 0d. per statute acre, and under the second lease £90 per foot per statute acre for each mine, and the average thickness of the Higher Bent Mine was 2ft. and the Lower Bent Mine 2ft. 3in., or an average of 1s. per ton.

The quality of these mines is first class.

The Little Mine.

This mine was worked at Lowside Colliery, and the royalty paid was £100 per statute acre, and the average thickness was two feet, or say eightpence per ton.

This mine was of good quality, and oftentimes sold along with Black Mine at Lowside, and several engineers requested to have a proportionate mixture of four-fifths Black Mine and one-fifth Little Mine.

Mountain Mine.

This mine has been worked at the following collieries:—The Barrowshaw Colliery, the Hanen Colliery, the Sholver Colliery, the Bankhouse Colliery, the Jubilee Colliery, and others.

The royalty paid was equal to about sevenpence halfpenny to one shilling per ton.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XIX. SESSION 1887-8.

The ORDINARY MEETING of the Members was held on Tuesday, April 10th, 1888, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOSEPH DICKINSON, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society, namely:—

Mr. SYDNEY ARTHUR SMITH, Mining Engineer, 18, Booth Street, Manchester.

Mr. JAMES GRUNDY, one of Her Majesty's Inspectors of Mines.

ON THE ARTIFICIAL REPRODUCTION OF MINERALS AND ROCKS.

By Mr. VAUGHAN CORNISH.

In the mode of treatment of my subject in the present paper I shall be guided by the circumstance that I am here as a chemist addressing geologists. The application of the facts I shall bring before you to geological problems can be better made by the geologist than by the chemist. I shall, therefore, refer but slightly to such applications, and devote myself chiefly to a description of the methods employed in mineralogical synthesis. These methods having been

developed in the laboratories of the chemist and will consequently be less within the usual range of the geologist's reading.

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It has frequently been the subject of remark that the products obtained in the ordinary processes of chemical work generally differ in important particulars from those naturally occurring minerals which have the same chemical composition. Thus, Barium Sulphate is precipitated by double decomposition as a fine amorphous powder, very different in appearance from the mineral Barytes. Again, Sulphide of Zinc is precipitated as a white amorphous powder, which appears to have little in common with the mineral Blende. The silica separated in ordinary chemical operations is not Quartz,—nor is the alumina so obtained Corundum. Lastly, by the fusion of silicates we generally obtain a glassy mass, differing altogether from those crystalline aggregations which constitute eruptive rocks. Such discordancies led to the belief formerly entertained that the processes by which minerals were formed in nature were in no way related to the conditions of the chemical laboratory. Not only were enormous pressure and terrific temperature invoked at every turn to account for these differences, but immense periods of time were supposed to be needed for the formation of, perhaps, a single crystal. The last consideration would naturally act as a deterrent from experimentation, since to the minds of many it would appear useless to undertake this class of work now.

It is to the scientific men of France that we owe the modifications of our ordinary chemical methods by which a large proportion of naturally occurring minerals have been reproduced, as well as certain associations of minerals constituting an important class of eruptive rocks. The methods which I will now proceed to describe have been elaborated by the French workers during the last forty years.

The products obtained by them are in all cases of small size, and the identification of these products with natural minerals needs all the resources of micro-crystallography and often of micro-chemical analysis. Into the methods of determination I cannot enter here, but I may mention that the examples given in the paper, only include cases where this examination appears to have been conducted with adequate care.

In the case of many insoluble substances formed in the wet way by double decomposition, it is found that the assumption of crystalline form depends merely on the rate of reaction. If this be retarded sufficiently, we obtain products identical with the natural minerals. This has been shown to be the case with Barytes, Anglesite, Witherite, Fluor, and others. The devices employed by Frémy, Macé, and others include, connection of the liquid by a thread of asbestos, dialysis through parchment or a porous partition, and the placing of cracked flasks containing the liquids in a vessel containing water, into which the liquids slowly diffuse through the cracks.

H. St. Claire Deville has shown that by frequently repeated heating and cooling in water of a substance almost insoluble (as Sulphate of Barium), an amorphous precipitate may be worked up into crystals. The small quantity of substance dissolved on the first heating deposits on cooling in minute crystals. These grow further, as the result of the second heating and cooling operations. As the double process is repeated, the larger crystals grow continually at the expense of the smaller, since they present, relatively to their mass, a smaller extent of surface to the solvent.

Here we have a case, where the amount of effect certainly depends on the time. It is in such cases, where repeated change of conditions produces an augmented effect that I should be inclined to attribute potency to those prolonged periods of action so frequently invoked. In other cases, if

the effect is to be increased by prolonging an action, the conditions must remain absolutely constant throughout. Such a constancy of conditions is scarcely in accordance with our usual experience of natural phenomena.

It is to H. St. Claire Deville that we owe the extended application of the "mineralising" action of certain volatile bodies, as hydrochloric acid and hydrofluoric acid, which may be caused to effect the crystallisation of an amorphous substance or the transportation of a crystalline substance. The mineralising agent leaves no trace behind in the product, and, its work done, disappears from the scene. The method is especially applicable to the formation of minerals such as Haematite, Casiterite, the Oxide of Titanium, in its three forms, and Corundum.

As an example of this method, I will instance the reproduction of the three forms of oxide of titanium by Hautefeuille. By passing a current of hydrochloric acid gas over an alkaline fluoride and the amorphous precipitated oxide of titanium, he obtained, when the substances were strongly heated, Rutile; when the heat was not so great the second form, Brookite, was obtained; whilst the third form, Anatase, is only deposited in those portions of the apparatus where the temperature is below 100° C. By various modifications of method Hautefeuille was able to reproduce not only the three mineral species of oxide of titanium, but even the varieties of each of these species.

The superior solvent powers of volatile substances under pressure at high temperatures was utilised by Séuarmont for the reproduction of the sulphides, as Pyrites, Blende, and Proustite. He heated the ordinary precipitated substances in a sealed glass tube, with a solution of sulphuretted hydrogen, which had been saturated under pressure. The substances dissolved, and on cooling, separated out in the forms of the naturally occurring crystals.

Similarly, carbonates, as Siderite and Magnesite, were

obtained in the characteristic rhombohedra by heating them in a sealed tube, with water saturated with carbonic acid under pressure.

It is, however, frequently necessary to employ pressures far higher than those thus obtainable. The apparatus employed by MM. Friedel and Sarasin for operations conducted in the wet way at a high temperature under pressure, consists of a strong steel tube lined inside with platinum, lest the super-heated water should attack the steel. The method of closing is as follows :—Between the steel cover and the tube is a lamina of platinum which, being squeezed out when the cover is screwed down, serves to render the closure more certain. Four large screws, each secured by a nut at either end, pass through the lid and the upper (projecting) portion of the tube. The tube is furnished at either end with a similar arrangement, this facilitating the cleaning of the tube. Such an apparatus may be heated to 500°C., or a dull red heat. It is important that the temperature should be maintained constant during the prolonged period of these operations. For this purpose a cast-iron stove is employed capable of accommodating six of these tubes. In the same stove is placed the porcelain bulb of an air thermometer, which serves at once to indicate the temperature and, being placed in connection with a Darsonval's regulator, to regulate automatically the supply of gas for heating the stove.

Daubrée, who first employed an apparatus similar to that described, obtained well crystallised quartz by the action of water on glass. More recently, Friedel and Sarasin have transformed amorphous silica into Quartz and Tridymite. By heating together silicate of potash, silicate of alumina and water, they obtained at the same time Quartz and Orthoclase. It must be observed, however, that the orthoclase obtained does not present the form known as the Carlsbad twin, and that the quartz is rather the quartz of veins than that of eruptive rocks.

There has been recently described in *Nature* the apparatus by which Cailletet has obtained temperatures up to the melting point of platinum whilst operating under pressure. The pressure is obtained by passing gas, previously compressed by a mercury pump, into a strong steel cylinder. Through the lid of the cylinder pass rods connected with the poles of an electric battery, which are within the cylinder. By means of the electric discharge the temperature can be raised to the fusion point of platinum. The employment of this apparatus may be expected to give results beyond the reach of former methods. Its great advantage lies not only in the high temperature obtainable but in the circumstance that this is obtained by heating the substance experimented on directly, whilst the materials of the cylinder are less strongly heated, and hence the apparatus is less liable to deterioration by use. This advantage is possessed also by the electrical furnace for smelting refractory ores. Cailletet has repeated the experiment of Hall on the conversion of chalk to marble. Whilst a crystalline product was obtained, as in Hall's experiment, the *fusion* of the carbonate was not observed. Hall stated that in his experiments the carbonate was fused, and this statement has been frequently quoted. It must be borne in mind, however, that Hall was ignorant of chemical analysis, and possessed no adequate means for the determination of his products.

The experiments of Spring on the effect of pressure alone, without an elevation of temperature, are of great interest. The powdered substance operated on is placed in a small steel cylinder, exhausted of air, in which works a piston driven by a strong steel lever, to the extremity of which weights are attached. At a position near the point of application of the weights, the lever is supported by a stirrup attached to a screw working in a nut; the screw having a fine thread and being furnished with a large milled head. The lever descends on the turning of the milled head, and

by this artifice the pressure is operated so slowly that the temperature of the experimental cylinder is not raised by more than half a degree centigrade. The pressures obtained in the experiments ranged to 10,000 atmospheres. By operating on copper and an excess of sulphur, a block was obtained with a crystalline fracture, and possessing the composition of cuprous sulphide. The excess of sulphur was disseminated through the mass. It is to be observed that in the combination of copper and sulphur, to form cuprous sulphide, there is a diminution of volume, 126 parts by weight of copper, and 32 parts by weight of sulphur, occupying 138 volumes; whilst 158 parts by weight of cuprous sulphide, occupy only 100 volumes.

By the employment of this method, Spring was not able to effect the conversion of chalk to marble. A pressure of 5000 atmospheres gave merely a mass possessing a coherence and texture similar to that of the sticks employed for writing on the blackboard.

I will now pass to the consideration of the method of igneous fusion by which alone have been obtained associations of minerals constituting veritable reproductions of eruptive rocks. The constant failure of the earlier workers to produce by igneous fusion any member of the Feldspar group, the most important minerals of many eruptive rocks, discouraged further work in this direction. MM. Fouqué and Lévy, however, attacked the subject in 1878, and in the course of three years' work succeeded in reproducing a large variety of the basic feldspathic rocks. The rocks of the acid and intermediate series, however, have as yet resisted all attempts at reproduction.

The considerations which guided Messrs. Fouqué and Lévy in the adoption of their experimental method, were as follows:—

Since the temperature of fusion of a crystalline substance is above that of the glass which results from it, the melt

must be raised above the fusion point. Secondly, this temperature must be maintained for a considerable time, in order that the particles may have opportunity to group themselves in the viscous fluid, in which they must be supposed to move but slowly.

Lastly, it is observed that in many eruptive rocks there appear to have been two epochs of crystallisation. Thus, in Olivine Basalts, the Olivine crystals appear to belong to a first epoch of crystallisation, the other constituents of the rock being grouped round them in microliths. The experimental operation must therefore be divided into two periods.

The substances employed were placed in a platinum crucible of 20 cubic centimetres' capacity, enclosed in the furnace of Leclerc and Forquinon. The position of the crucible in the furnace can be changed as it is desired to alter the temperature. The constancy of the temperature in any position is assured by the employment of an arrangement due to Damoiseau, for obtaining a constant blast of air in the blowpipe. In this arrangement the blast is regulated by the rate of escape of water from the orifice of a conical vessel. The apparatus employed enables any temperature up to that at which platinum melts, to be maintained constant for practically any length of time.

The reproduction of an Olivine Basalt was conducted as follows:—Materials of the requisite composition were placed in the crucible and raised to a white heat. This temperature was maintained for 48 hours. The crucible was then brought to the position where the temperature was that giving a bright red heat, and maintained thus for other 48 hours. A sample taken out at the end of the first half of the operation showed, on cooling, crystals of Olivine, accompanied by Magnetite in a brown-coloured glassy base. The product obtained at the end of the second half of the operation showed the same crystals of Olivine in a base composed of long microliths of Labradorite, and short microliths of Augite.

together with more Magnetite. The characters of the products formed, as revealed by microscopic examination, agree in every detail with those of the natural minerals, and the rock formed is precisely similar in character to certain natural Basalts of Auvergne.

Among the many rocks prepared by MM. Fouqué and Lévy, may be mentioned an artificial Leucite Lava. It is interesting to note that the Leucite of the artificial product presents the well-known rounded angles of the natural Leucites of Leucite Lavas.

The same workers have applied their method successfully to the elucidation of the composition of the so-called Plagioclase Feldspars.

Of the method of reproduction of minerals by fusion with a flux I will say little, since the conditions appear to diverge widely from those obtaining in the natural formation of minerals, and are consequently of less interest to geologists. The method is of importance nevertheless in that it has been applied to the extension of the number of members of certain mineral species (as the Apatites); and in that it may be employed to discriminate the true from the accidental constituents of minerals. Thus certain substances in the act of crystallisation invariably include matter from the magma out of which they crystallise. By varying the nature of this magma, it is evident that the necessary constituents of the mineral may be ascertained.

Mr. Stirrup moved a vote of thanks to Mr. Cornish for his very valuable communication on a branch of geology which, he said, had not often been brought before the Society. Mr. Cornish had given them a very good idea of the accurate methods now employed in the investigation of some of the problems of Chemical Geology. They knew, of course, that the metamorphism of many rocks was brought about by pressure or by heat, but there had been

various opinions expressed as to the mode of operation of these forces, and few attempts had been made, in England, to pursue inquiries of this kind. As Mr. Cornish had said, the investigations had been carried out chiefly by Frenchmen, and the members were much indebted to the lecturer for the excellent diagrams and the explanation of the elaborate mechanical appliances used in these experiments. The motion was seconded by Mr. Wild.

The PRESIDENT, in putting it to the meeting, said: I have not, for a long time, listened with more pleasure to any paper than I have to this. It is not that there is anything specially entertaining in it, but it really gives you some correct lines of thought to go upon; it lets you see the processes of nature as carried out in accordance with certain definite, fixed and unalterable laws. It is seldom that we have been able to produce mineral forms as they appear in the earth, as Mr. Cornish tells us now some of them have been produced, though under certain altered circumstances. Pressure and heat seem to be the two great forces which are brought in to obtain some of these results. There are so many points to think of in this paper, that I should not like to commit myself to any summary of it off-hand—indeed I am not capable of doing it; but there are one or two points that any of us can form opinions upon, and ask questions about. There is the transformation for instance, of chalk into marble. This, if I mistake not, has been done on a large scale in nature. What we have as the chalk in England is a beautiful white marble in the North of Ireland, with the corresponding fossils and corresponding position in the geological series,—but one is white marble and the other is chalk. In the neighbourhood of that chalk, also, we have the conversion of many of the surrounding beds into basalt, showing that there had been some action going on—probably heat—which had caused the change. Then, again, there is the formation of artificial

basalt by fusion. I have fused basalt many hundreds of times, but I have never been able to fuse it into the same form in which I obtained it from the ground. There is a certain crystalline granular structure in the natural basalt, whilst you find a glassy structure after fusion. Sixty years ago Mr. John Leithard, of the Ashton Moor lead mines, made some experiments by passing slow galvanic currents through mixtures of different kinds of rock, and by continuing that slow action for months he gradually formed the different kinds of rock back again, each into its own stratum. However, the paper read by Mr. Cornish was not one for consideration off-hand.

Mr. CORNISH, in responding, said: The experiments on carbonate of lime were undertaken in order to test the point whether marble was really, as had been said, formed from chalk. It was supposed, from the evidence of the surrounding rocks, that the action had been that of heat; but it was well known that by heating chalk they simply drove off the carbonic acid. It was converted into quicklime. The question, then, was—How was it possible for heat to have acted when they knew that heat destroyed the substance? This led Hall, at the end of last century, to make some experiments in order to see whether some modifying action might not be produced by pressure. His paper was entitled: "On the action of heat, as modified by pressure," and he showed that, when the pressure was sufficient, the carbonic acid did not come off, and the chalk was converted into marble. With regard to the basalts, and the experiments by fusing them, the results of the earlier experiments were precisely similar to what the President had stated. It was known that, in fusing a crystalline rock, you obtain a glassy substance. Then it was found that by heating basalt a sufficient length of time, and allowing it to cool slowly, a rock not absolutely glassy could be obtained. Messrs. Fouqué and Lévy attacked the problem in the light of these

experiments and of their own observational work, and the result was embodied in the elaborate work to which reference had been made.

BOULDERS IN COAL SEAMS.

Mr. STIRRUP read the following communication from Mr. Herbert A. Woodward, which was accompanied by three boulders taken out of the Trencherbone Mine, at the Newtown Collieries:—

"As it is probable I shall not be present when the paper on boulders is read to-day, and which I regret, I send you three boulders lately found in the Trencherbone Mine, at our Newtown Collieries; they were all found singly and in much the same position as those described in a former communication, viz. resting on a parting in the coal seam of a quarter of an inch thick of smudge (see Part XVI., page 410, Sketch D), at depth of 950 to 1,000 feet from the surface; 20 or more have been found in an area of 1,000 square yards very similar to those sent. You will notice that one has a peculiar groove in it, and that the smallest is of a quadrangular shape and not rounded off at the ends."

ON THE OCCURRENCE OF BOULDERS AND PEBBLES IN THE COAL MEASURES.

By MR. W. S. GRESLEY, Assoc.M.INST.C.E., F.G.S.

Mr. Mark Stirrup having quite recently gone so fully into this most interesting subject (see Transactions of the Manchester Geological Society, Vol. XIX., Part XVI.), the object of this communication is to supplement his reference to certain boulders, obtained chiefly from the coal itself, by quoting instances of the occurrence of others which have either come under the writer's special notice, or have been otherwise heard of or described.—Boulders and pebbles not only found embedded in coal seams and lying in the roof, but "erratics" occurring in the *floors* or *underlays* of coal beds—

Taking those from out of the coal seams or from the overlying beds first, we find that Phillips, in his "Manual of Geology," 1855, p. 225, mentions the finding of a boulder composed of quartzite or hard sandstone in a coal bed near to Newcastle-on-Tyne.

In the Natural History Museum of that town is a group of small boulders (some being pebbles), amongst which is one from the "Main" seam* at Cockfield pit. Another one came from the top of the Three-quarter† coal at Lands pit, 1867. Eight others in the same museum are not labelled. The composition of all these stones seems very similar, namely, grey quartzites. They are all well rounded.

In the celebrated grindstone quarries of Messrs. R. Kell & Co., near the same town, a rounded foreign pebble was found last year. It occurred in the centre of a large block of stone, at a depth of 15 feet from the surface of the bed. Not knowing the exact locality of the quarry, the writer is unable to say from what geological horizon the pebble came.

Near Burntisland, at Pettycur, in Fifeshire, a large lump of transported rock of volcanic origin, 17in. by 15in. by 12in., was found embedded in the Carboniferous strata some years since, but it had the aspect of a bomb rather than of a boulder. Pebble-like stones, of a hard reddish-brown rock, are sometimes met with in the flagstone quarries in the neighbourhood of Leeds.

The author has seen a notice of a boulder found in the coal, at Norbury, near Stockport.

Several instances of the finding of water-worn and travelled boulder stones have come from the coal measures of North Derbyshire. Mr. G. Buxton, formerly of Ilkeston, relates that about thirty years ago, one was met with in the "Lower Hard" coal seam, near that town, but what became

* Probably the lowest workable seam of the upper coal measures of County Durham is the same as the Brockwell seam of Wallsend.

† There are several seams in Northumberland and Durham called "Three-quarter."

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is said to have been obtained from out of a bed of coal son
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In 1877, Prof. A. G. Lebour, gave a paper in which he
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veins."

Fig 1 $\frac{1}{100}$

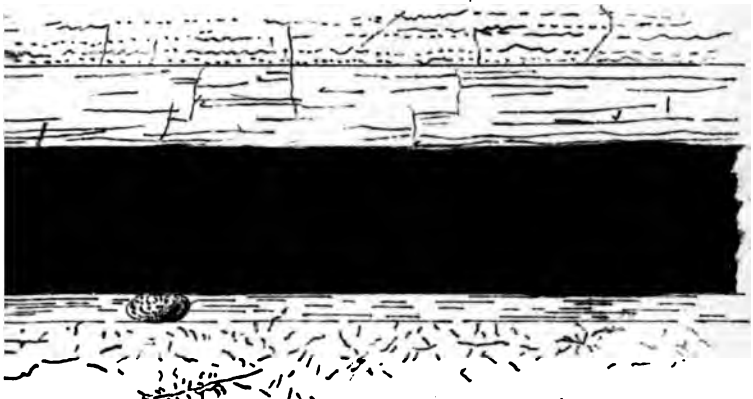

Fig 2 $\frac{1}{60}$

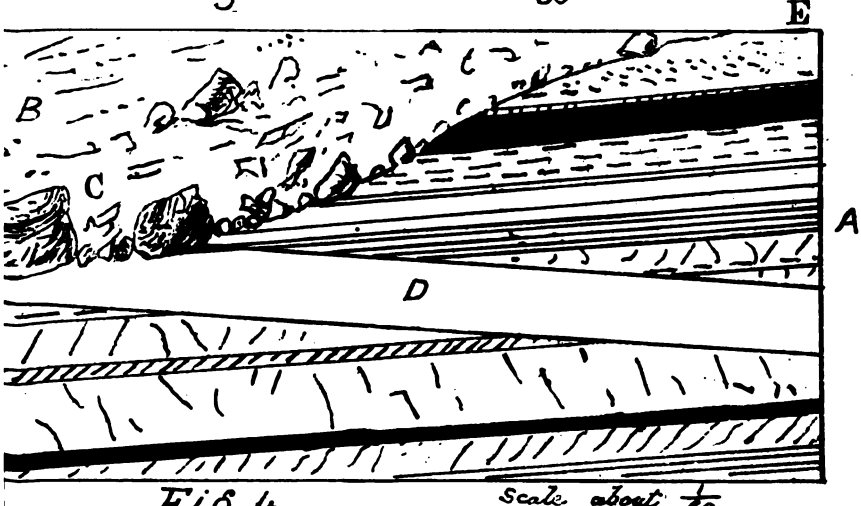

Fig 4 Scale about $\frac{1}{60}$

...ures denuded towards West.
Breccia occupying eroded coal-measures.
'Erratics' with numerous smaller stones.
Being driven E. to W. to prove coal beyond.

of it he does not know. A rounded boulder of white quartz is said to have been obtained from out of a bed of coal somewhere in the Midland coal field, and the writer understands that Mr. A. H. Stokes, F.G.S., Inspector of Mines, saw it.

Again, at Oakerthrope Colliery, Derbyshire, about the year 1855, in the roof of the "Bottom Soft" seam, at a depth of 135 yards, a layer of well-rounded boulders and pebbles (? Quartzite), was seen by Mr. Aaron Slater, the then bailiff there, who tells me that the boulders lay just on the top of the coal-seam in a lenticular patch of about which took the place of the regular sandstone roof. The area of the roof occupied by these stones (which were seen in a heading), was about 15 feet by 7 feet. He described them as "hanging like eggs in the roof." The author mentions it particularly, because it is an instance where the matrix of the pebbles was *shale* which had probably replaced the sandstone, and, according to Slater's description, not a case of a local patch of shale between the coal-seam and the roof rock. (See Fig. 1). He assured me the stones were *bonâ fide* well-rounded, very hard boulders and pebbles, and not nodules of Ironstone. This is all he could tell me about this very interesting and curious discovery. In North Wales, the late Mr. Binney said, a pebble had been found in the Rydgaled mine. And Mr. Farrimond, in 1862, exhibited what is described as "a rounded piece of white quartz, which had been found in a bed of coal" (the Lower Mountain Mine of Dunkenhalgh Park, near Church.) (See Transactions of the Manchester Geological Society, Vol. III., page 342).

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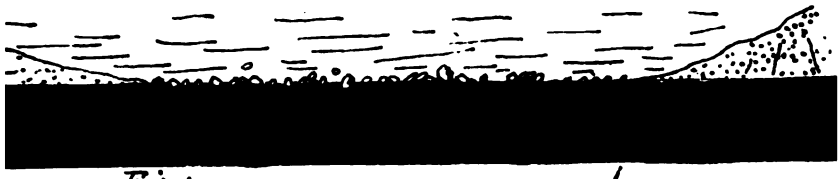

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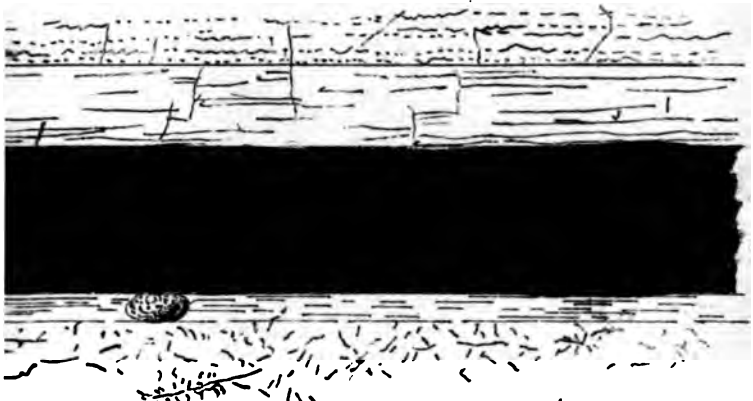


Fig 2 $\frac{1}{60}$

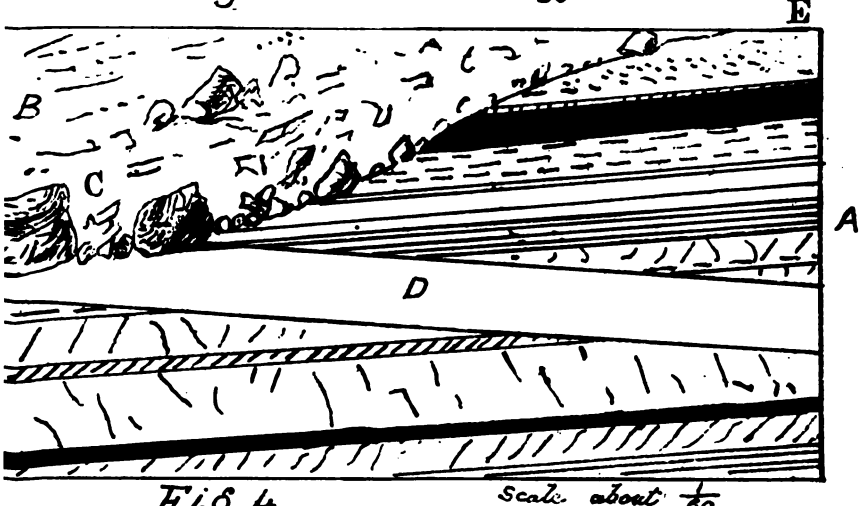


Fig 4 Scale about $\frac{1}{60}$

zures denuded towards West.
Breccia occupying eroded coal-measures.
'Erratics' with numerous smaller stones.
being driven E. to W. to prove coal beyond.

In the carboniferous rocks, near Dublin, we are told that granite and other rock-fragments are met with.

In 1865, the late Mr. W. Molyneux, F.G.S., reported the occurrence of "large rounded quartz pebbles in shales and ironstones, lying near the base of the Upper Thick measures at Apedale," North Staffordshire, namely, about the middle of the coal measures of that coalfield, which are about 6,000 feet thick; and he says "in another case a large siliceous water-worn boulder, some pounds in weight, was met with at a fault at a considerable depth in one of the pits in the Cheadle coalfield." In April, 1887, the *Leeds Mercury* published some account of discoveries of boulders *in* and *overlying* coal beds at Wortley, by Mr. Charles Brownridge, F.G.S., who had read a paper entitled "Notes on Four Boulders found in the 'Black-Bed,' coal and overlying shales and ironstones at Wortley. The "Black-Bed" overlies the "Better-Bed," and the boulders described occurred at about 30 feet below the surface. The largest (a coarse gritstone) measured 2 feet 6 inches by 2 feet, had a fairly smooth, polished surface, with slight striæ. This one was found in the shale just over the coal seam. "The other three (pebbles) were much smaller in size, varying from 11 inches by 9 inches to 3¼ inches by 2½ inches, and were all found embedded in the 'Black-Bed' coal itself. One of the specimens was a fine-grained grit, the other two being quartzites." The writer is indebted to Mr. Brownridge for the above particulars.

In a colliery in Shropshire, a water-worn pebble of lead ore was taken (by Mr. George Spencer) from the top of a coal seam in the workings. He also met with a boulder, or rather a pebble, about 4½ inches in diameter (? quartzite) in the roof of the "Main" coal* in the Heather Colliery, Leicestershire. Two years ago the writer obtained

* This "Main" coal is probably one of the "Lount" seams, namely, near to the base of the middle coal measures.

a smooth, flattish, quartzite pebble from the middle of the "Roaster" coal of Coleorton, in the same district as Heather. This bed of coal underlies the "Lount" seams, and is at Coleorton about 2 feet 10 inches thick, and the pebble lay at 12 inches from the top of it. This pebble appears to contain worm-burrows. In 1883 a scattered group of four much larger stones was discovered in the "Lount Nether' coal at the same mine, all completely embedded in the coal, and 500 yards away from them another boulder of the same character was found in the same coal. Professor T. G. Bonney, who very kindly examined one of these erratics both macroscopically and microscopically, tells me that it is like some of the more compact quartzites in the pebbles of the Bunter in Staffordshire, and in the Loch Maree district; and that a similar rock occurs on the Torridon road, about three miles from Kinlochewe, in Sutherlandshire, Scotland. These boulders and pebbles from the "Lount" seam at Coleorton were found about 80 or 90 yards from the side of a "horse" or "wash-fault" of a width of 100 yards; but that they could have any connection with one another seems unlikely. A year or two since the *Brisbane Courier* noticed the discovery, at the Clifton Coal Mines, in Queensland, of "a layer of water-worn quartz pebbles, (was) found on the top of the coal." This was at 80 feet from the surface. New Zealand also has furnished very similar pebbles. Before passing on to some account of boulders or pebbles found underneath coal seams, it may be well just to refer to the occurrence, in South Wales, of pebbles composed of cannel coal, met with in the roof of a seam of ordinary coal, by Sir W. Logan, in 1840. These pebbles occurred in a seam of indurated clay. He also discovered coal pebbles in the Pennant sandstones in considerable abundance (Proceedings of the Geological Society, Vol. III., page 276). The late Sir H. de la Beche also found coal pebbles in several areas of the coalfield both in Monmouthshire and Glamorganshire (Memoir of the Geological

Survey, Vol. I., pages 193 and 194). Mr. H. K. Jordan, F.G.S., mentions the occurrence of granite pebbles associated with coal pebbles near the base of the Pennant series. Also of coal pebbles up to the size of a hen's egg in the sandstone forming the roof of the "Rock Fawr" coal seam near Bridgend. (Quarterly Journal of the Geological Society, Vol. XXXIII., page 932.)

Again, in the Kanawha Valley, West Virginia, Mr. Stuart M. Buck, of Coalberg, stated, in 1881, that in a sandstone roof "in one place where a fall of roof occurred, exposing a section of sandstone, it showed a number of blocks of coal embedded in the rock; not stringers or layers, but angular blocks of 'splint' (hard, dull-lustred, coarse, fibrous, pure coal), as well-defined as though they had been picked off a coal car and placed in the sand while it was being deposited." In the same year, when driving a heading partly in the "Main" coal and partly in the underbed, at Moira Colliery, in Leicestershire, the Manager (Mr. Buxton) noticed a large angular or rugged block of coal completely enveloped in the floor of the seam, measuring about 1ft. 7in. across, and about 1ft. thick. That this lump of coal must have been an erratic, appears evident. The writer never saw it, as it was broken up and lost sight of before he heard of its discovery.

Travelled Stones in Underbeds of Coal-seams.

About 20 years ago, lying immediately beneath the "Little" or "Five-feet" coal-seam, at Church Gresley, in Derbyshire, (Ashby-de-la-Zouch Coal-field), at a depth of 630 feet—a seam of great regularity and occupying a position 180 feet above the "Main" coal which lies as nearly as possible in the centre of the coal-measures of the district, (see Fig. 3) a boulder, described by the late Mr. Molyneux, F.G.S., of Burton-on-Trent, as "composed of hard, crystalline sandstone, dotted with small, angular quartz pebbles, having a smooth, well-worn surface: it measures ten inches in diameter by six inches thick, and

in this latter particular corresponded exactly with the thickness of the clay (the underclay of the 'Little' coal-seam) in which it reposed." Fig. 2 shews the relative position of coal, underclay and this remarkable wanderer. The writer has made every effort to find out what became of this stone, but no trace of it seems to be had. However, three years ago, a group of five little hard, light grey, quartzite pebbles were unearthed by the "holders" in the same seam in the same mine, whilst last year a sixth was met with about 100 yards away from the other five. The rock of which this last mentioned pebble is composed is a quartz conglomerate with a few grains of some black mineral (probably *tourmaline)*. All these are well-rounded, and, excepting for the colour of their surfaces are just such pebbles as we may pick up any day where Bunter Conglomerate occurs at surface. They were all found embedded in the "underclay" just below the coal as shown in Fig. 2.

Now it is a point worthy of special note, that the underbed in question is, strictly speaking, not a fire-clay, but it rests upon a seam of inferior fire-clay in which may be seen the usual so-called *Stigmaria* roots and rootlets (Fig. 2). The underbed containing the erratics is a deposit, arenaceous rather than argillaceous; it is a distinctly laminated stratum, and contains numerous fossil fragments of Lepidodendra, Sigillariæ, &c., and sometimes Stigmariæ; but the writer (although he has for many years been on the look-out for an instance) has never yet seen or heard of such a thing in this bed, as fossil roots which could be traced to the coal seam above; nothing, in fact, of the nature or in the form of the stump of a tree. The bottom of the coal itself bears well-defined impressions (? flattened bark) of tree stems and other parts of plant-remains.

A small, very smooth (highly polished in one place) oblong pebble of quartzose rock, of a yellowish tint, was met with

last year, entirely enveloped in a seam of fire-clay (locally called "the marl") four feet thick, being the underbed of a 10-inch coal seam in the same district, namely, at Littleworth, near Ashby-de-la-Zouch. This horizon is 220 yards above that of the six pebbles just mentioned, or the highest known seam of coal but three or four in the coal field. The underclay in question has a rather laminated or bedded structure, and its fossil contents consist of a few Stigmariæ (having no resemblance to the roots of trees); many plant-like *in situ* fossils, probably of aquatic nature, and not, by any means, yet fully examined or described; usually found nearly horizontal, but sometimes turning up nearly vertically towards the coal, composed largely of bright, pure, brittle coal, with a very smooth, wrinkled, or striated surface; patches of fossil charcoal (carbonized plant tissue), or "mother of coal;" pinnules of ferns, &c. The pebble was taken from near the middle of this clay seam, which extends over many square miles. The above particulars of this, and of the "Little" coal underbed, are given here in order to show that in them we seem to have no evidence that they were ever the so-called "old surface soil" in which flourished the forest trees, &c., of the coal seams, but rather were originally layers of comparatively soft mud, or silt, in which grew species of stigmaria-like and other plants, &c., and in which drifted material was buried; and from the position of the various pebbles described, we can only conclude that they were quietly dropped into the mud, or sand, before the coal seam began to accumulate or grow.

Again, quoting Mr. Stuart M. Buck, of Coalberg, U.S.A., in a paper contributed by him in 1881 to the Transactions, American Institute of Mining Engineers, Vol. X., he says: "I have also had two singular specimens brought to me from the slate, immediately underlying the splint. (Coalberg Vein, Kanawka Valley, West Virginia.) One was a piece

of milk quartz, and the other of flint,* both rounded, and of about ten pounds weight."

Travelled Boulders and Pebbles, therefore, are probably not so very uncommon in underbeds or fire-clays.

In the Leicestershire coal field then, we have four, if not five, different geological horizons of these erratics (see Fig. 3.) The writer is uncertain as to whether the Heather Colliery pebble referred to was on the top of the seam correlating with the "Middle" or the "Nether Lount."

In regard to the more or less pebble-like concretions, occasionally found enveloped in coal beds—stones unquestionably formed *in situ*—two or three varieties are known, viz.: Pebble-like lumps of Iron Pyrites in brown coal, of the Jurassic rocks in Servia; Ditto in coal-seams of Leicestershire, two of which are on the table; the "Coal-balls" referred to in Mr. Stirrup's paper; and some singular nodules of clay Ironstone, described by Herr D. Stur as having been found in a coal-bed in Austria (see Sketches exhibited), one of which was partly of ironstone and partly quartz, from which specimen, Stur rather argued that the boulders of granite and gneissic rocks found in the coal there, were originally ironstone nodules, converted *in situ* into granite, &c., a most unlikely change, and, with our present knowledge, altogether inconceivable.

The analysis of two of these balls of Ironstone, gave:—

I.	Per cent.	II.	Per cent.
Insoluble in Acids.....	13·03	Insoluble in Acids	30·20
Carbonate of Lime	61·43	Iron Pyrites	6·45
,, Magnesia	2·86	Carbonate of Lime	29·01
,, Iron (oxide)..	16·13	,, Magnesia..	4·33
,, Manganese (,,)	1·73	,, Iron (oxide)	25·09
Clay	2·49	Clay	2·22
Water, Organic Substances, and Loss	2·33	Organic Matter, Water, &c.	2·70
	100·00		100·00

* Probably a very fine-grained quartzite, the writer would imagine.

The writer is indebted to Mr. Bragge, of Swadlincote, for the translation of these analyses.

So much for the facts.

Upon the question as to *how* the boulders and pebbles got into the coal or into the underclays, the writer would like to call attention to one or two points.

So far as his own personal observations have gone, every stratum out of which an erratic stone has been taken, shows from its laminated structure that in all probability it was either deposited or accumulated in or under water, and, therefore, these boulders must have been transported by the agency of water too. It is not intended to be given as the author's opinion that coal-seams are drifted vegetable matter, but, if not to *water*, to what other cause are the *laminæ* of *all coal-beds* to be attributed ?

Now, if the travelled pebbles and boulders were carried by being entangled in the roots of trees, brought down by floods, and then let drop to the bottom, it is evident that carboniferous trees grew in other positions, besides in the coal-measures themselves; and, looking at the remarkable absence of connection between the so-called *stigmariæ* in underclays and the overlying coal-beds; and at these so-called "old soils" seem to show that they are deposits formed by water; and at the fact that coal itself is stratified in a remarkable manner, we have to admit that the presence of erratics in underclays affects the whole question of the mode of formation of coal-seams. We should be glad to have the opinion upon these underclay Boulders, of those who hold that our coal-beds and their underclays represent the remains of forest growth with great trees deeply and firmly rooted in the clays.

It seems only natural and reasonable to suppose that one and all of these erratics were brought in by one and the same agency, whatever that might have been. Detached blocks of rock have been found firmly attached to gigantic

seaweeds which have been torn from the ocean bed during storms, and drifted long distances by currents.

With regard to the idea that these boulders have fallen from melting ice-bergs whilst they floated over the spot; it is commonly supposed that the climate of the period prevented their formation, but what proof have we that the vegetation of the coal epoch was unsuited to an arctic climate? Botanists are beginning to admit that the organisation of plants is not by any means a safe criterion to take as indicating the conditions and surroundings under which they exist. The writer believes that Sir Joseph Hooker goes so far as to admit that the Sigillaroids and Lepidodendroids may have flourished in regions of extreme cold.

Even the travelled blocks and pebbles of coal associated with coal-seams are of the greatest interest geologically.

Their existence proves one thing, namely:—that long before the completion of the coal-measures, coal-seams had become completely mineralized and consolidated in some places; also, that upheaval and denudation had taken place, and that either the vegetable matter soon become coal, or that the time through which the coal period ranged was vastly greater than many of us might imagine.

The finding of the lead ore pebble mentioned above, shows that veins, &c., of that mineral are no modern deposits.

One word by way of caution to be observed in this connection.

As the writer possesses a Boulder of quartzite and a Pebble of conglomerate (containing fragments of felspathic rock, lava bits, &c.? schorl, according to Prof. Bonney), which were found along with two more or less weathered, waterworn, and striated, travelled boulders weighing from 10 cwt. to 20 cwt. each, and many other besides at a depth of about 160 yards in a drift in a colliery near Burton-on-

Trent, about ten years ago, which turned out on investigation to have been discovered not *in* but *resting upon* the coal-measures, and to belong to the breccias at the base of the Permian series of the district; it by no means always follows that because such erratics are met with *in* Coal-Mines, that they must of necessity have been obtained from the Coal Measures.

Fig. 4 explains the manner in which these Permian boulders got into the coal-pit in question.

In conclusion, the writer begs to apologize for the rather crude way in which this communication has been brought before the meeting, but he has to plead want of more time for preparing it. He trusts however that his remarks have been of some interest, and that they may help to elucidate the question at issue, namely, the Geological History of the Erratics of the Coal Period.

Mr. Wild in moving a vote of thanks to Mr. Gresley, said he would have been glad if that gentleman had been present, in order that they might have discussed the subject more fully. The subject (he continued), is one in which I take especial interest. These pebbles are what we find usually on the tops of coal seams, and if we can satisfactorily solve the problem of the formation of the coal beds, there is no doubt it would help us to explain the presence of these boulders. My impression is that it is possible to suit both the growth *in situ* theory and the drift theory at the same time. If a tract of country, 50 or 100 miles square, had a very rank vegetation upon it, and subsidence began to take place, say over the central half of that tract water would begin to accumulate; trees there would cease to grow, and their remains would accumulate, and decay, being augmented by the growth of masses of low forms of moisture loving vegetation. Streams flowing into this depressed area would bring in a lot of drifted vegetation, and a deposit would

be formed, say 12 or 15 inches thick; then, probably a flood would bring down a quantity of mud, which would be spread over the already formed deposit. Fresh growth or drift again would go on from the surrounding flattish land, and gradually there would be formed over a large tract another deposit of moderately pure vegetable matter, that in course of years would be converted into coal. Upon that theory, the bed of coal would naturally be thicker in the centre of the depressed area, though not much; and I can quite see that there is a chance for both theories to be correct—that is, growth *in situ* and drift. On the first of these theories there might be formed a thick bed of peat or moss; on the second, there would be a great accumulation of drift stuff formed by the washing into the depressed area of vast quantities of decayed wood and vegetable matter of various kinds. The seat of the stigmarian roots would be under two depressed portions, though the coal immediately over it might be most of it drift. Then, supposing the sea had once overlain that area and had washed the abutting older rocks, causing a beach of rounded pebbles, or boulders, when the water retired from this pebbly beach, whether from upheaval or silting up, and vegetable growth went on betwixt it and the sea, it would remain in a comparatively quiescent state. Subsidence might set in more rapidly and continuously for a time, bringing on a repetition of sea-encroachment; vegetation would be almost lost sight of, and fishes and shell-fish inhabit the waters and muddy sediment so long as the conditions were suitable. At this point we seek the agency which has furnished us with those interesting pebbles and boulders. That they have undergone floatation and been loosened from some buoyant matrix—such as ice, or other dissoluble binding—seems almost certain, and in that case they would fall through the water upon the submerged vegetable matter, and press before them into the yielding mass the previously

deposited fragments of bones, scales, and teeth, and other indestructible remains of animal and vegetable life so commonly found resting immediately on coal seams, especially when succeeded by dark bituminous shale. There is one thing which seems to be lacking in the observations made; I think, when these boulders are found they should be cut out to see whether the stratification above has been disturbed. That would show whether the boulder went down directly, that the sea encroached and covered up the mass of vegetation, or whether it sank further through the shale. My impression is, they came in about the time the fish were living whose remains we find, and have been deposited quietly on those fish remains, I should not expect them to descend far through any mud or shale to get into the coal. I think if we can arrive at a satisfactory theory to account for the formation of coal in the way we find it—in some cases three inches of cannel on the top; in others six inches of cannel at the bottom of the bed—which seems almost to imply the drift theory—it strikes me this explanation of the carriage of the boulders will follow as a matter of course.

Mr. STIRRUP seconded the vote of thanks, and it was carried unanimously.

The PRESIDENT said: I so recently gave you my views on the subject of these so-called boulders that I have little to add now. Careful observers say that if you keep repeating a certain point over and over again in time you can actually obtain believers. The statement about these boulders in coal seams has been repeated over and over again, until it is almost becoming a current belief. Mr. Gresley has sent us a cautiously reasoned paper, and I think he uses the term "pebbles" rather more frequently than "boulders" which I think is very proper. They are pebbles, or concretions, and not boulders.

Mr. STIRRUP: I think he uses the term simply as a distinction of size. The pebbles being the smaller ones.

The PRESIDENT: I should call them all pebbles. Many of these which are described are what an ordinary iron-stone miner would call balls—balls of iron-stone. There are different kinds of these balls. There are those found in the Millstone Grit of Northumberland. Balls have also been found in the rock near Halifax, and below that which is so extensively quarried for flagstones all round Bacup and Rochdale, and in the township of Spotland, particularly about Facit—balls as round as marbles; and you may see in many of the flags you walk over the hole, half a sphere, which a ball has come out of. I believe that in the formation of the coalfields there has been no intrusion from without. It has been one growth. There have been no boulders intruded. If any medical gentleman is here, or any lithotomist, he will smile in his sleeve, and wonder what some of his lithic or phosphatic productions may hereafter be called.

Mr. STIRRUP said: There are many points of interest raised in Mr. Gresley's paper, which, if time permitted would be well worth discussing. Mr. Gresley is apparently a strong supporter of the theory that all coal is drifted material, but I think, with Mr. Wild, that it is very likely—indeed, it may be said to be almost certain—that we have coal beds composed of vegetation grown on the spot, and also others formed of drifted matter. Of the coal beds in the valley of the Loire we are distinctly told, by the great authority on them, that they are composed of drifted material, and there seems no doubt, judging from the microscopical examination of the fossil vegetation, that some of the trees grew on higher and drier elevations than what we may assume to have been the case with a great part of the vegetable matter which constitutes our coal beds, and that afterwards this upland vegetation was carried down by

streams to the lower regions. But of course this is apart from the subject matter of the paper—which is, the occurrence of boulders in coal seams.

Some of the instances of boulders or pebbles in carboniferous rocks, quoted by Mr. Gresley, are too indefinite to add much to our knowledge, but they show that their abnormal occurrence has attracted the attention of many observers.

That pebbles and stone-balls such as mentioned by the President, are found in grit and flagstone quarries, are facts well known to all observers, and their origin well understood, but these are quite different things from what I understand as boulders, which are undoubtedly erratics differing altogether from the rocks of the coal measures. I hope that now the attention of the members has been again called to this subject after the lapse of a quarter of a century, we may yet obtain more facts to guide us to a satisfactory solution of the questions at issue.

The PRESIDENT said that what they had heard from Mr. Cornish about the formation of certain minerals, might lead to some explanation of the mode in which these pebbles were found in the coal seams. He reminded members that in various places, at the junction of formations which lay unconformably with each other, pebbles were found. One remarkable bed, known as the pebble bed, was many feet in thickness—he might say yards in thickness—of nothing but pebbles; yet that was underlaid and overlaid by solid rock. There was a similar bed running through the coalfield of Lancashire, and what was remarkable, it overlies the Trencherbone mine—from which many of these large pebbles that Mr. Woodward has sent were taken. There was no more fickle mine than that in the Lancashire coalfield. At Wigan, it was known as the Wigan 9 ft.; elsewhere, it was the Wigan 6ft.; then, coming across the big

fault at Hindley, it became a 5 ft. seam, known as the West Leigh 5 ft. It came through to Atherton as the 5 ft., and further east it was the Trencherbone. At Manchester, this rock was deeply tinged with iron; westward, it became a white rock, and near its base there was this pebbly structure, which was quite remarkable. In some places this rock would eat out the whole of the coal, and leave nothing but the roof and the floor meeting, and that would sometimes extend to as much as half a mile without any coal in the ground at all. A few days ago, when in this seam, he brought a piece of the rock away, thinking that possibly it might not have been noticed. (The specimen was handed round.) It would be seen that on the one side the structure was pebbly—on the other the pebbles ran into the rock and were, in fact, part and parcel of it.

Mr. Cornish, in reply to the President, said, with regard to the comparison he (the President) had drawn between the crystallisation of certain rocks and the possible mode of aggregation of these boulders, he did not think the cases were comparable. He did not suppose that by a consideration of the two together any light could be thrown upon the mode in which the boulders were formed. There were only one or two points in the paper about which he felt qualified to speak. As to the possible formation of granite from ironstone nodules, referred to in the quotation from Herr Stur's paper, looking at the analysis given, he said they would have to bring in a great deal more acid material or else get rid of half the bases—either one process or the other would be necessary to get the requisite composition to make a granite, and, even if they did that, there would be no reason to suppose that granite would be formed.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIX. VOL. XIX. SESSION 1887-8.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, the 4th May, 1888, in the Mining School, Wigan.

The President, Mr. JOSEPH DICKINSON, F.G.S., in the Chair.

The Honorary Secretary (Mr. MARK STIRRUP) informed the members that arrangements were in progress for a visit to some of the most important sections of the Manchester Ship Canal Works during the summer, under the conduct of the engineer of the undertaking, Mr. Leader Williams.

Mr. Daniel Adamson had also kindly offered to lead an excursion to the important iron-stone beds of the Lower Lias formation in the neighbourhood of Frodingham, Lincolnshire. This excursion promised to be of great interest to geologists, as the beds are very fossiliferous.

MINING RENTS AND MINERAL ROYALTIES.

The PRESIDENT said that several papers would be read, which had been sent in to the Honorary Secretaries, in continuation of, and in reply to, the one recently read before the Society by Mr. Percy, on the subject of Mine Rents and Mineral Royalties :—

He would first submit to them an extract which he had made from the work of Mr. Dunn, who was an authority on this question, and it would perhaps most fitly precede the other papers. The President then read the following extract from Mr. Matthias Dunn's treatise on the "Winning and Working of Collieries," 2nd edition, 1852, who says in treating on the

VARIOUS MODES OF LETTING COLLIERIES.

The principle upon which rent is reserved by the proprietor, in the leasing of collieries, is governed, in different districts, by ancient custom, or by some peculiar circumstance; but the basis is founded upon the probable profit to arise from the fair and proper working, and the extraction of the greatest quantity of coal possible from the mines. In many cases, customs were established under circumstances subsequently altered; but, as I before observed, all are more or less intended to bear upon an efficient working of the mine, and the disposal of the produce. Hence the now universal custom of reserving the rent upon one or the other of the following principles, viz.:—

1. Rent upon tonnage.
2. Rent upon the amount of sales.
3. Rent by the acre of coal, one foot thick, and so in proportion.
4. Rent certain—viz., a certain sum per annum, independant of the quantities of coal that may be raised from the property. This principle of letting, however, is now nearly obsolete.

1. The Rent upon Tonnage

Is prevalent over the north of England, and other parts in which the amount value of the coal is variable; one price being allotted to the round coal, and a proportionate rent to that of small, passed through a screen of certain defined

dimensions. It is a necessary principle in the Newcastle collieries, because in the vending of the coals, whether to manufacturers or to the sea, freightage and railway dues attach to the transit; and if the coal owner consigns to a broker, the actual returns of sales of these coals can only be procured after the lapse of considerable time, and under such devious and complicated accounts, that it would ill suit the landlord to embarrass himself with the investigations necessary to adapt the rents to a per-centage of the amount of sales Hence the general custom of levying the rents per ton respectively of round coal and of small coal. These rates, of course, differ according to the relative advantages of locality, the value of the coal, cost of winning, expense of working, &c.; but they may be stated in the north of England at for round coal 6d. to 12d., and for small coal 2d. to 4d. per ton, and in Scotland and elsewhere, from one twelfth to one fourth of the value sold. At the same time, a certain annual rent floats over the property, payable on account, until the periodical settlement of the quantities be made.

In the provision for rent there is always sufficient time allowed to win and open the colliery before the commencement of the payments. I will here enumerate the general clauses inserted in colliery leases.

1. Term of years determinable on the part of the tenant at any or at certain periods of the lease, by giving twelve months' notice in writing; or, in case of the exhaustion of the coal, or the mine becoming unworkable to profit.

2. Certain rent, payable half-yearly, without regard to the working of coals, or at the option of the landlord; so much per ton for round coal, and so much for small passed through a screen of certain dimensions; or so much for coals just as they are brought from the mine, but sold, the colliery consumption being thereby allowed rent-free.

3. Tenants to be liable to all surface damages (generally double the annual rent), and at the expiration of the term to restore or pay for such damaged land, according to the arbitration of disinterested persons.

4. Power to make up shorts—for rent prepaid, that is, by working up quantities of coals at the agreed rate per ton, such privilege to remain either for certain periods or during the whole term,

5. Lessee to leave certain defined barriers of coal against adjoining properties.

6. Power of working other properties by *outstroke* underground, paying for the same according to circumstances, for one or more of the privileges, as follows :—

	Per ten of 48 tons.
For breaking the barrier or underground-way leave ..	2s. to 3s.
For shaft rent, drawing up the shafts	2s. to 3s.
For way leave rent over the surface	2s. to 3s.

7. Landlord reserves all power and privilege of examining the mine or the books, measuring the waggons or tubs, &c., with power to levy for over-measure.

8. All buildings of brick or stone to be left to the landlord at the end of the lease.

9. Landlord to have power to purchase any part of the stock by giving — months' notice previous to the determination of the lease.

10. Lessee covenants to work fairly and orderly, according to the most approved principles of mining, or to some specific contract; otherwise, in case of misconduct, to be liable to damages, with power for the landlord to re-enter the lease. The same applies to unpaid rents.

11. Lessee allowed to dig clay, quarry stones, &c., for the purposes of the colliery, rent free.

12. Lessee bound to leave the colliery in a fair tenantable condition, with proper passages to the whole coal, &c.: otherwise liable to damages.

13. General clause for reference, in case of dispute upon any subject arising out of the lease.

2. Leases upon the Amount Value Sold.

Throughout Scotland and many other coal districts it is customary to levy, for rent a proportion of the amount value of coals sold; and this rent varies from 1-5th to 1-15th, according to the value of the coal and the cost of producing it. In some cases, a colliery is re-let which is already won and in course of working: whereas another is let to win at great risk, and demanding much capital. This description of rent, therefore, is payable upon the value of the coal at the pit top; so that the expense of delivering it at the depôt, or place of shipment, is deducted from the value at such distant point before estimating the rent.

This is a very fair principle of proportioning rent; but where the coals are conveyed to distant markets by the proprietor, and the sale is devious, it becomes difficult, as before observed, to apportion the value.

3. Leases per the Acre.

Throughout Lancashire and the neighbouring counties it is common to let or sell coal by the Cheshire acre, which consists of 10,240 square yards; the statute acre being 4,840. The lessees are also bound to a certain rent, equivalent to so many acres per annum, at the agreed price per acre. In this case the tenant is left to work the colliery to the best advantage, in regard to getting out all the coal possible, inasmuch as it is assumed to be paid for as totally worked. The price per acre differs according to the ever-varying circumstances of collieries; but in order to apply the principle to every variety of seam, it is levied at so much *per foot thick per acre*, the said footage ranging from £40 to £140 per acre; and in order to arrive at the proper quantity worked each half year the average thickness of the seam is taken, and the quantities computed accordingly;

each year's measurement being differently coloured upon the plan, and the workings balanced and accounted for, along with the certain rents payable on account.

However equitable in principle this mode may be, it leaves too much of calculus in the office of surveyor; for many parts of the mine may become inaccessible between one period of measurement and another, and may also be irregular in thickness on account of bad coal, bands, or other frequent causes. By force of custom, however, the different seams in neighbourhoods where they are known, assume a sort of current value which becomes sufficiently satisfactory.

This mode of estimating the rent is in favour of the lessee whose knowledge, experience, and capital induce him to carry on the most improved system of working, whereby either a larger gross quantity of coal than ordinary may be produced from the mine, or a greater proportion of large coal yielded; the rates of rent having been founded upon the *average* production, or the general practice in the district.

The available produce of ordinary mining may be stated at three-fourths of the gross contents; and of those three-fourths, a certain proportion consists of small coal, over and above that which is left underground. If, therefore, by an improved mode of working, these available proportions are amended, it amounts to a reduction of the ordinary rent.

	Tons.
A Cheshire acre of coal one foot thick may be said to contain	3000
Suppose to be left underground, in pillars and small coals	800
Available	2200
Suppose small coal at surface and colliery consumption	600
Produce of large coal, per foot thick, per Cheshire acre	1600

4. Leases for certain Rent only

Were common in former times, in cases of grants from the crown, or of manors where the existence of coal was uncertain or problematical, or in properties so small or so isolated as to be incapable of ordinary rule. The want of the clause for tonnage has been known to invalidate colliery leases in the Court of Chancery.

Mr. Oswald Walmesley was then called upon to read the following paper which he had prepared:—

MINE RENTS AND MINERAL ROYALTIES.

By Mr. Oswald Walmesley.

Preliminary Observations.

The subject of mine rents and mineral royalties has recently attracted some considerable amount of public notice. A subject like this, which comes rather under the head of Political Economy than that of Geology or Mining, is liable under some circumstances to be treated from a partisan point of view for political purposes. It is, therefore, very satisfactory that the neutral ground of this Society should be available for the discussion of the subject on its merits. It is a subject in which I take a special interest, and on which I may claim the right to have some opinions by reason of having been for the last eighteen years up to the commencement of the present year in practice as a solicitor in a mining district, and of having in that capacity had to deal with a large number of mining leases, on behalf sometimes of mine owners and sometimes of lessees of mines. This is my excuse for venturing to offer the following observations for the consideration of the members of this Society. Before proceeding, however, I take this opportunity of congratulating Mr. Percy upon his able and interesting paper; and,

if I cannot agree with all his views, I can at least admit that he has made out as strong a case as could well be presented in favour of those views. It is not possible that the whole of Mr. Percy's paper could be reviewed within reasonable limits, and I therefore propose to deal only with those portions of it which seem to me to call for special observation.

Parties interested in Mines and Minerals.

In order to make the position which I propose to take up in reference to this subject intelligible, I will premise that there appear to me to be four parties who are jointly interested in mines and minerals. These four parties (taking them in the order of their connection with the mines) are the following, viz.:—

1st.—The mine owner.

2nd.—The mining lessee or employer.

3rd.—The miner or employed.

4th.—The consumer.

These parties having a joint interest in the mines, have also as between themselves separate and distinct interests which each of them is entitled to have duly represented and considered in any question which may arise respecting the mines.

Now, my first observation with regard to Mr. Percy's paper must be that he has treated the subject with which it deals mainly from the point of view of two only of these parties, namely, from that of the employer and the employed. It is only fair that the special interests of the other two parties should be considered. This will explain how it is that—although I wish, and shall endeavour to have due regard to the interests of all the parties—it may possibly appear that in the following observations I treat the subject more particularly from the point of view of the two parties whose interests I consider to have been somewhat overlooked

by Mr. Percy, namely, that of the mine owner and the consumer.

Ownership of Mines in this Country.

My next observation has reference to the statement that the mines "once the property of the nation have been lost through want of knowledge that they existed or by carelessness on the part of the state authorities." Mr. Percy does not dispute the present legal title of the surface owner to mines, but the suggestion he makes in the words just quoted, *if verified by history* would undoubtedly be deemed by many persons to afford some justification for interference with the present legal position and rights of the surface owner with respect to mines. I cannot, however, help thinking that a very slight ramble into the ancient history of the ownership of mines in England will save us from even a passing feeling of regret, such as Mr. Percy seems to have experienced that an available opportunity for wiping off the National Debt has been lost. The history is fully set out in "The case of mines" decided in the reign of Queen Elizabeth, (in the year 1568,) and reported by Plowden. The case shows that from time immemorial the English law has recognized the right of the owner of the surface to everything beneath it except "Royal mines" which are held to belong to the Crown by reason of the Royal prerogative, on account of the special excellence of the thing, and to assist the Crown with funds for the defence of the country, and for the supply of coinage. These "Royal mines" are mines of gold and silver, all other mines being known by contradistinction as "base mines." At one time the Crown also claimed as "Royal mines" any mines of copper, tin, iron, and lead, with which gold and silver were found to be inter-mixed, and this claim was supported by the legal decision to which I have referred; it was, however, abrogated by two Statutes passed in the reign of

William and Mary (1 W. and M., c. 30, and 5 W. and M., c. 6) for the express purpose of encouraging the working of mines, though the Crown retained a right of pre-emption with respect to such mines at certain rates which would by no means be considered nominal, even at the present time.

Ownership of Mines in Scotland.

As regards the ownership of mines in Scotland (to which Mr. Percy has referred in his paper), I find that, even before the Union of the two Kingdoms, the law in each seems to have been analogous, viz.: that "royal mines" belonged to the Crown, and "base mines" to the individual. I have referred to the old Scotch Statute, mentioned by Mr. Percy; and, although it is somewhat difficult to understand (being written in a strange compound of Latin, French, and Scotch), it appears to me only intended to apply to mines then claimed as "royal mines," and even with respect to such mines to contain provisions (which by-the-way do not appear to have been referred to by Mr. Percy's correspondent), under which the freeholders could work, let or deal with such mines on rendering to the Crown one-tenth part of the produce. I may say that a much earlier statute (to which I have also referred), passed in the reign of King James the First, of Scotland (in the year 1424), shows that the King *then* only claimed mines in which three half-pence worth of silver could be extracted from one pound of lead. (It is stated that 1½d., at that date would be equivalent in value to about 2s. 6d. at the present day), and it would appear by the same statute that permission was given to the subject to take even "royal mines" on payment of 11d. for each pound to the Crown As to the alleged neglect by "State Authorities" (which term can in this instance only apply to the Crown). I think that any careful reader of English History will find that from the time when Richard Cœur-de-Lion lost his

life in asserting his right to "treasure trove," the Crown has not usually been remiss in claiming the royal rights and prerogatives; but, as history shows that the Crown has never even claimed any reservation of base mines from the subject's ownership of the surface, it is clearly unnecessary to spend further time in showing that such mines could not have been lost by the Crown.

Ownership of Mines Abroad.

And in connection with the subject of the ownership of mines in this country, it may be convenient to refer to Mr. Percy's remarks as to the ownership of mines in other countries. I think that I may fairly assume from the resemblance of the figures quoted by each, that Mr. Percy has based his remarks on this subject upon the particulars given by Sir Lowthian Bell in his book on the "Iron Trade of the United Kingdom;" but, whilst Mr. Percy is careful to tell us that in Germany, France, and Spain, the ownership of coal and ironstone, and in Belgium, the ownership of coal is vested in the State, he omits to tell us (what appears equally in Sir Lowthian Bell's book) that in the United States of America the ownership of the minerals goes with that of the surface. The "Reports by Her Majesty's Representatives abroad, on Mining Rents and Royalties, and the Laws relating thereto," (published in the form of a Blue Book, since the date of Sir Lowthian Bell's book,) show that there are in fact great varieties in the tenure of mines on the European continent, some of them much more favourable to the owner of the surface than the instances quoted by Mr. Percy: for instance, in Belgium, iron-ore belongs to the owner of the surface: in some parts of Germany the surface owner is entitled to a very considerable portion of the mines: in some parts of France he receives a royalty, not much less than that usually charged in England: in Sweden and Norway the ground owner is entitled to one-

half of the mines: whilst in Italy the ownership varies in different parts of the country between the State and the surface owner. But would it follow that we should consider our law on this subject defective, if it did not accord with that which prevails on the European continent? Our English notions about the rights of private individuals are in many respects different from the ideas which are prevalent abroad, and many things are left in this country to the ownership and enterprise of the subject, as for instance: the ownership and establishment of railways, and other public undertakings, which in most foreign countries are retained by the State. It may fairly be contended that the rapid development of the mineral resources of this country is due to their being the property of private individuals, and there is no more reason why we should be guided by foreign precedents with a respect to the ownership of mines, than we should feel ourselves bound to adopt the foreign system of protective duties, and army conscription.

Condition of Mining Industries and other Industries at Home and Abroad.

To pass on to Mr. Percy's remarks on the present condition of our mining industries, it cannot be denied that they have, on the whole, for many years been greatly depressed, and that the depression still continues; but is the depression confined to the mining industries or to this country alone? Has there not been an equivalent depression in agriculture and in every trade and industry; and who can read the official reports from foreign countries without admitting that the depression has been *universally felt?* Mr. Percy refers to the latest financial statements of three of the most important mining companies in the United Kingdom, and finds that, whilst there has been but little profit made by any of them, in only one case has there been any actual loss. I have obtained particulars from the reports of some of the

German Chambers of Commerce, from which it seems that things in that country are even worse than here, and that the German colliery proprietors have been working for years with great loss. For example, 30 collieries in the "Upper Official Administration of the Dortmund District," in the year 1885, suffered the loss of 6,000,000 Marks (£300,000). It may seem strange to Mr. Percy that in these official reports one of the chief causes alleged for the unsatisfactory state of things is the inability of German to compete with English coal; a clear proof of this being, that in Hamburg English coal is sold at 1s. per ton less than German (Westphalian) coal. From £1,500,000 to £2,000,000 have been paid every year recently for English coal imported to the north German ports. It should also be borne in mind that when prices were good, as in 1873, no trade or industry in England was more prosperous than the mining industry. How many fortunes have been made in our own time and in our own neighbourhood through the coal trade, in some cases by gentlemen who (to their own honour be it said) commenced their careers as working men! And why should it be taken for granted that times are never to improve again as they have done before in recurring cycles by some mysterious working of economic forces which it is almost impossible to trace? It must also be borne in mind in considering questions relating to mining matters, that mining is always to some extent of a speculative nature and subject to many vicissitudes. How can this be better illustrated than by the fact that in a certain district in the neighbourhood of Wigan very satisfactory results are being obtained by colliery proprietors even at the present time in consequence of an unexpected discovery of cannel. The information which Mr. Percy gives as to the development of the American mining industries is certainly more interesting than encouraging to us, and it must of necessity

be admitted that no amount of legislation or enterprise will enable English coal to be delivered at Pittsburg at 1s. a ton to compete with the natural gas we are told about; but it must not be taken for granted that the requirements of the whole world are yet so fully provided for that there is no chance of our finding fresh outlets for the produce of our English mines. What about the so-called "Dark Continent," which is now so rapidly being streaked with light? Would not any improvement in general trade lead to a renewal and increase of the ocean carrying power of the world (which in so preponderating a degree is supplied by this country) with a corresponding result upon the languid pulse of our mining industries? Nor is it altogether unlikely (though by no means to be desired) that fresh continental wars, in which (thanks to our insular position) we are fortunately not likely to be involved, may paralyse foreign industries with a similar result to the mining industries of this country which is attributed to the last struggle between France and Germany.

PROFITS THROUGHOUT LEASES SHOULD BE CONSIDERED.

My next observation must be that having regard to the successive periods of inflation and depression, mine-owners have clearly a right to ask that the profits from the commencement of the leases should be considered relatively to the royalty rents, and not merely the relation of the two at the present period of depression; that the period when pig iron touched £10 a ton, and coal passed a sovereign a ton, should be brought into the calculation as well as the present period, when nothing like one-half of those prices can be realised. No doubt some leases were granted on exaggerated terms at the period of the inflation before referred to; but such leases form only a small proportion of the existing leases, and have in many cases been revised. Mr. Hewlett's opinion as to mining matters is undoubtedly of the highest value; but I do

not feel bound to admit that the conclusions we should at first sight be disposed to draw from his opinions, in the way that they are presented to us by others, must necessarily be correct; for instance, when he tells us of the increased cost to the lessees, resulting from recent legislation for the protection of mines, is there nothing for us to put in the other side of the scales? There must surely be some compensation for the increased cost of such protection by the reduced number of accidents occurring in mines; and what is the increased expense compared with the inconvenience, loss, and misery resulting from such great explosions as have, unhappily, from time to time occurred in this country, and which it is the main object of the legislation to prevent?

Royalties at Home and Abroad.

But it would be idle to dispute that the burthens on mining lessees are greater than they used to be, and (although it is unreasonable to ignore altogether the possibility, nay, even the prospect, of an improvement) it is by no means likely, or in the interests of the consumer to be desired, that the famine prices of 1873 will ever occur again. It is but right therefore that we should consider whether anything can be effected by fair and legitimate parliamentary action, or otherwise, to encourage the mining industries during the still gloomy period of depression. But, before dealing with this most important part of the subject, I think it will be more convenient for me to make the few observations I have to offer with respect to the particulars as to royalties in this country and abroad, given in Mr. Percy's paper. I have no intention of following Mr. Percy into the details he has collected, or of attempting to criticize the estimates he has made with respect to the royalties charged in this country; though it must be very difficult to arrive at a perfectly correct estimate of the percentage of price per ton corresponding to such royalties, seeing that they vary not only in

different counties, but also in different districts, and even at different mines in each district, according to a vast variety of circumstances, whilst the selling price of the minerals, which must be brought into the calculation, also varies. If the parliamentary enquiry, which is proposed, should be made, no doubt we shall obtain further data for forming an accurate opinion on the subject.

With respect to foreign royalties, however, I must point out that the Blue Book, to which I have before referred, shows that in the various countries in which the ownership of mines is vested in the State, the charges in the nature of royalties are often far from being nominal. In order to illustrate what they in fact amount to, I have obtained particulars of the payments made in respect of a colliery in the Dortmund District of Germany, producing yearly about 68,000 tons of coal, and find that, including the direct tax (which, by the way, is two per cent. on the gross value at the time of the output of the produce taken from the mine, and not, as Mr. Percy leads us to suppose, a tax only on the net profits of the undertaking) supplemented by Government charges on account of insurance funds and other beneficial institutions, the total charge amounts to the sum of 12,363 marks (about £618), without reckoning anything for land occupied and damage to the surface.

General Arguments cannot be based on particular cases.

No general argument can be based upon special cases such as are quoted by Mr. Percy, in reference to individual instances of charges made by lessors in respect of mines. If such cases are fully enquired into, it may often be found that satisfactory explanations may be given for what at first sight may appear to be cases of hardship. I must own that when I first read Mr. Percy's paper I was somewhat

startled at what appeared to be an undue demand on the part of a lessor in the case of the Dolcoath mine, where he tells us that a fine of £25,000 was levied by the lessor before granting the renewal of a lease. By a strange coincidence however, it happened that on the same day that I read Mr. Percy's paper, I received the prospectus of "The Anglo-Austrian Tin Company, Limited," under ordinary circumstances I am afraid that this would have been consigned to the waste paper basket: but it so happened that the word "Dolcoath" caught my eye, and accordingly I looked through the prospectus. My surprise was great when I found that the most attractive feature contained in the prospectus was a report from Captain Josiah Thomas, described as "Manager of Dolcoath," in which he states that he has examined the mine to which the prospectus refers, and he makes the following remark (printed in large letters in the prospectus): "I may here observe that this is about the same average produce as the tin raised at Dolcoath mine, where we are at present making a profit of about £50,000 (Fifty thousand), per year."

As the report is dated 30th January, 1888, I at once came to the conclusion that the fine levied by the landlord has not had an altogether ruinous effect upon the Dolcoath undertaking even in these depressed times. I have since been favoured with particulars showing that certain special circumstances existed under which the owner was justified in asking, when the opportunity presented itself, for a larger slice of the cake of which his lessees had previously been getting the lion's share. And if there have been cases in which lessees have had to bear heavy burthens, there have also been cases in which they have got by far the best of the bargain, striking instances of which are well known to every one acquainted with mining matters in this country.

Rating of Royalties.

One other matter as to which I must offer some observations is Mr. Percy's statement that "royalties pay no rates." This is a statement which has recently been very urgently put before the public, and has, I believe, given rise to a considerable amount of misconception. There can be no doubt that the impression sought to be conveyed, and which is accepted by some persons without sufficient consideration, is that a certain class of property is exempted from rates, and that if such property were charged with a fair proportion of the rates, the rates on other property would be considerably reduced. This impression is altogether incorrect, and is bound to be removed by a very slight consideration of the principles on which rating of property is based, and of the arrangements which are usually made between lessor and lessee. The main principle on which all descriptions of property are rated is the same. The property is rated on the annual rental value (an allowance being made for rates and taxes, insurance and repairs). Take the case of house property. Houses are rated on the annual rental value, after making the slight deductions before referred to. It is merely a question between the landlord and the tenant which pays the rate—sometimes it is the one and sometimes the other; but if the tenant paid a rate upon a house based upon the annual rental value and the landlord had to pay a rate upon the rent again, surely that would amount to rating the same property twice over. It is exactly the same with mines. The annual rental value is rated each year: in the case of mines which are let upon lease it is no doubt usual for the lessees to pay the rate because leases of minerals usually contain a covenant to that effect and the rents are calculated on that understanding; but this is merely a matter of bargain between the landlord and his tenant which does not

affect the public. If, however, after the tenant had paid the rate based on the annual rental value of the mines the landlord had to pay a rate on the royalties, which *are the rents* of the mines, surely that would be rating the same property twice over. In the case of a mine owner who works his own mines, if it were to be held that royalties should be rated apart from the mines the owner would first have to pay his rates upon the annual value of his mines, and would then have to take a sum equal to the amount of the royalty he would pay in case he were a lessee, which would be again the annual rental value of his mines, and would have to pay a second rate on the same annual rental value. Even assuming that there may be some case for an alteration of the usual arrangement with regard to payment of rates as between lessors and lessees, that would not in any way affect the general public by diminishing the rates upon other property. It has been suggested that when bargains are made for letting mines the lessees overlook the covenant for payment of rates, and that the landlord, by a bit of sharp practice, throws upon them unawares all the burthen of the rates; but anyone who has had any practical experience of the lengthened negociations which generally occur, and the searching investigations of the terms of mining leases which usually take place before such leases are completed, will know that lessees are not to be deluded in such a manner. Mr. Percy has also discovered that in some cases ironstone lessees can deduct from their royalties one-half of all local rates, and seems to conclude that he has found a fresh cause of complaint, as he asks "Why one law for ironstone royalties another law for coal?" Here, again, a little study of history comes in useful. The liability to rates of mines other than coal mines (coal mines having been rateable since the reign of Queen Elizabeth) was for the first time established by the Rating Act of 1874; and, as the leases of

ironstone mines granted previously to that date would generally have been entered into on the understanding that the mines were not liable to be rated, it was by the same Act equitably provided that, where at the commencement of the Act the lessee was exempt from payment of rates and afterwards became liable to pay them, he might deduct one-half of such rates from his royalty. The Act does not, however, apply to the case of any mines where the lessees, knowing that their mines were liable to be rated, have specifically contracted to pay all rates. There is, therefore, no distinction between the incidence of rating in the case of coal mines and of ironstone mines which have been let on similar conditions and under similar circumstances; and, in the case of ironstone mines held under leases granted since 1874, as in the case of coal mines, the payment of all the rates is usually made by the lessee. But the subject of rating is somewhat abstruse, and when people who do not look far into things for themselves are persistently told that royalties pay no rates without having it explained to them that the property in respect of which the royalties are paid is fully rated, and that the method of payment is merely a matter of arrangement between lessors and lessees, they are apt to imagine that there is something wrong. Were it only to prevent such an impression, it might be desirable that in future leases some new system could be adopted for division of rates between the lessors and lessees, regard being given to that fact in considering the terms of letting, though I do not see that any altogether satisfactory system of division could be arrived at except one which should vary from time to time according to the beneficial value of the different interests in the property. There is much more which might be usefully said on this subject of rating, but it would be outside the scope of the present discussion.

Proposals for Relief to Lessees.

I now come to the methods approved of by Mr. Percy, for alleviating the difficulties with which lessees have to combat under the present depressed condition of the mining industries. It must be remembered that Mr. Percy does not look forward to any possible improvement in trade; the only prospect he can hold out to the mining lessees seems to be that by arrangement or legislation, they may obtain relief from the burthens they have undertaken in connection with their leases; and, following the fashion of the times, he very soon begins to talk about interference with contract; and seeks to justify his suggestion that there should be such interference in the case of mining leases by reference to a number of legislative enactments, the most important of all, as he says, being the establishment of a land commission (in Ireland). I cannot for one moment admit the parity of the cases. I have the pleasure of being personally acquainted with a large number of colliery proprietors, and I am happy to say, that their personal appearance would of itself preclude me from comparing their case with that of the starving peasantry of Ireland! I do not for one moment deny that the public necessity will justify state interference with contract; but, I would recommend gentlemen, for whom this cry of interference with contract seems to have a special fascination to study the constitution of that most truly Democratic country in the world, the United States of America, and they will find that it is there recognised that such interference should not take place without very grave necessity; for, although there are 38 States and 7 Territories in the Union, having in most respects the right of making their own respective laws, it is specially provided by the Constitution that no State shall pass any law imparing the obligation of contracts, and (to quote from the essay on the Constitution of the United

States by Mr. Phelps, the United States Minister in England, published in the February number of the *Nineteenth Century*), the result of this fundamental law is that "No contract, whether executed or executory express or implied derived from State Charter or from *private agreement* can be affected by any subsequent legislation, either in any material feature of its obligation, or by depriving its parties of a remedy for its violation," whilst, although (as in England), real estate, may under special circumstances be taken for a public use in the true sense of the word, that is, an actual use by the general public, it cannot be taken from one man and given to another on the ground that the public is to be incidentally or indirectly benefitted, and in all cases where property is taken for public use it must be paid for before it is occupied. This should assist us in considering the measures which are being placed before the present Session of Parliament in the interest of mining lessees.

Bill as to Cornwall and Devon.

The first is a "Bill to amend the Law relating to Mining Leases in Cornwall and Devon." Now it is well known that the whole law with respect to mines in the counties of Cornwall and Devon, is different from that prevailing in other parts of the country. In those counties an ancient immemorial jurisdiction has been enjoyed by a court known as "The Stannaries Court," for dealing with questions relating to mines, and it by no means follows that laws which might be passed regulating questions relating to mines in those counties should necessarily be applied to the rest of the country; still there can be no doubt that, if all the principles involved in the Bill to which I have referred were admitted even within the Stannaries jurisdiction, there would be a strong precedent created for their adoption elsewhere. The Bill is intended in the first place to enable mining adventurers to acquire a particular district for their

operations, on having arranged with two-thirds of the owners of the minerals within the district by obtaining from the Stannaries Court a licence to work within the boundaries of the remaining owners, even without their consent, but on the same terms on which the majority of the owners have agreed to let their mines. The power thus sought to be obtained is somewhat high-handed, but may not be considered altogether improper in a district where there are many small owners, and where there is an established court specially qualified to make equitable arrangements between the parties. In the next place the Bill is intended to entitle lessees to compulsory renewals of their leases upon terms to be settled in case of difference by reference to arbitration. An objectionable principle seems to me to be involved in this provision which I shall refer to later on. The Bill then provides that if land be damaged the lessor shall (notwithstanding any provision to the contrary) not be entitled to receive any penal sum, but only the fair market value of the land with an additional sum for severance and other consequential damage. The law of England does not favour penalties, and there is not likely to be much objection raised to this provision. The last provision, which seeks to entitle the lessee to all buildings erected by him during the term for mining purposes (notwithstanding any covenant to the contrary), is altogether opposed to the recognized principles of the law of real property in England.

Mr. Peace's Bill.

The other measure which is proposed to be brought in during the present session is Mr. Peace's "Bill for the Relief of Mineral Tenants," which is referred to fully in Mr. Percy's paper. The object of this Bill is to entitle lessees to a compulsory extension of the terms of their leases, for the purpose of enabling them to get minerals for which they have paid, by a renewal of their leases during a

further term not exceeding a period of one-third of the original term, without making any further payment in respect of the minerals, in other words, to supply renewal clauses which have not been bargained for in the leases without any further consideration to the lessors. The authority which Mr. Peace undoubtedly brings to bear on any measure which he advocates with reference to mining matters is almost unbounded, and it is with the greatest deference to his superior qualifications for dealing with the subject, that I venture to suggest that there are grounds for objection to his Bill in its present form; and I have all the more difficulty in urging those objections because I sympathize with the object which he has in view, and only differ from him as to the means which should with even-handed justice to all parties be adopted for effecting that object. He has appended a pithy memorandum to the printed form of Bill, setting out the grounds on which the measure is proposed, and supporting the proposal by reference to certain legal enactments, granting relief from forfeiture to lessees, and to the expressions used by Lord Cairns in the case of *Gowan v. Christie*, to the effect that a mineral lease resembles a sale. I must, however, point out that where the legislature has interfered on behalf of the lessee in the case of the enactment referred to by Mr. Peace, it has been solely for the purpose of preventing forfeiture of leases before the expiration of the terms for which such leases were originally granted, and that, in proposing a compulsory prolongation of the terms after the dates at which they would according to the leases, have expired by effluxion of time, Mr. Peace is asking the legislature to take a long step in advance of any previous limit which has been reached. It also appears to me that the quotation from Lord Cairn's judgment in Gowan *v.* Christie set out in the memorandum, does not really bear upon the question of extension of terms. In the

case of Gowan *v.* Christie, the lessee was not seeking to prolong the term of his lease, but to put an end to the term and abandon the lease, on the ground that he could not work the minerals to a profit (a contention which was absolutely rejected by the Court). Undoubtedly in some respects a lease of mines partakes more of the character of a sale than a letting, but in one vital respect, a lease is altogether different from a conveyance. This appears clearly from the very saying of Lord Cairns, quoted by Mr. Peace, that a mineral lease "is liberty given to a particular individual *for a specific length of time* to go into and under the land and to get certain things." The termination of the liberty at a specific time is of the very essence of the arrangement. But admitting the view that a mining lease has much about it in the nature of a sale, the rent representing deferred payments of the purchase money, if the transaction is looked at in the light in which it would appear if the purchase money, instead of being deferred, were paid down at the commencement of the lease, the comparison of a mining lease to a sale seems to tell rather against than in favour of Mr. Peace's proposal. When two parties agree upon a sale, be it for land, or for houses, or anything else, and the purchase money is paid down, the well known maxim of *caveat emptor* is always understood to apply and no one would in the absence of fraud attempt to set aside the sale, on the ground that the bargain had proved to be unremunerative to the purchaser. Mr. Percy's contention as to the moral right of a man to keep a horse or house or a farm for which payment has been made, scarcely adds much to the force of Mr. Peace's argument. Surely, if I hire a horse or take a house or a farm for a definite period, and, through my own want of foresight or even misfortune, I fail to get the use out of them which I expected during the specified period, I cannot object to give them up at the end of the hiring or tenancy. I think any

one who owned a house and had let it for a year, would be more than astonished if at the end of the year the tenant were to state that he had been obliged, say through illness, to spend the greater part of the year at the seaside, and to contend that the owner ought on that account to let him have the house for another year rent free! I therefore am unable, as yet, to see that there is any argument in favour of Mr. Peace's proposal that the Court should have power compulsorily to extend the term of a lease. Mr. Percy refers to this as "a mild proposal." I presume that he is not himself an owner of mines or he would scarcely characterise it by that term. When an owner has let a mine after a fair bargain for a term, he is, I submit, justified in expecting that during that term he shall be paid for the mine, and that at the end of such term the land may be restored and possession given to him so that he may again deal with the surface as agricultural or building land, free from the disturbance incident to mining operations; and I submit that it would be an undoubted hardship if he were compelled to let the mining operations be continued for a further term, against his will. Where the minerals left behind are valuable and there is no objection to a continuance of the mining operations, there can hardly be many cases in which mine owners who are in a position to do so, refuse to extend the terms of their leases upon fair and reasonable conditions. As regards the case of Trustees, I believe that Mr. Peace would confer a practical benefit on the whole community if he could get the legal disabilities removed which often stand in the way of equitable arrangements being come to, especially in the case of Settled Estates. A great advance in that direction has already been made by Lord Cairns "Settled Land Act," which has given power to tenants for life, to accept surrenders of leases and grant new leases, the effect of which is that, where during the progress

of a lease the length of a term is found to be insufficent or the conditions unsatisfactory, new arrangements may be and have already in some cases been come to; but the great difficulty is in the case of trustees who have at the present time little or no latitude in the way of making desirable and salutary concessions or remedying cases of hardship, and it must be remembered that under the Settled Land Act a tenant for life, in exercising the powers given by the Act, is considered a Trustee for all the parties interested under the settlement. But when it comes to a question of compulsory interference with existing contracts, I confess that I do not see, even having regard to the occasional loss by lessees of over-paid mine rents at the end of their leases, the existence of that public necessity which alone would justify such interference.

Fixed Rents.

The system of fixed or certain rents is in the present state of the law necessary in the interests of the mine owner; it ensures the rapid development of the mines, and is therefore advantageous to the workman and the consumer, and even a serious diminution of profits to the lessees is not of itself "a sufficient public necessity" to justify compulsory interference with the leases. As regards the position of the mine owner it is simply necessary to point out that he not only naturally wishes to ensure the receipt in each year of a fixed sum, but that if he did not do so, the result would be that the lessee might simply take the mines on speculation and hold them for years without paying any rent, perhaps hold them during the whole period of the lease for the purpose of preventing some one else from working them. In the face of numerous legal decisions showing that a lessor cannot rely as a safe substitute for a certain rent on covenants to work the mine, no owner could be so unwise as to place himself in the risk of tying up his mines for

years without any return. What I am saying is by no means imaginary. My late partner, Mr. Thomas Part, told me some years since of an instance where a lease of mines was granted without reserving a certain rent, nearly a century before, and, until a certain period before the date of our conversation, no coal had been got or any royalty received.

In another case he told me that he was a trustee of property in which a similiar lease was granted very nearly a century previously, and in that instance the mines had never been worked nor a farthing of royalty paid up to the date of our conversation. In consequence of cases such as these, the reservation of a certain rent has for many years been considered essential in the letting of mines. The objections already taken to Mr. Peace's Bill apply equally to the renewal clause in the Devon and Cornwall Bill.

Mine Owners should meet their Lessees in a generous spirit.

From what has been said, I think it will be seen that I am strongly in favour of every possible encouragement and even stimulus being given to mine owners, to induce them to assist and meet their lessees in a fair and generous spirit in the present trying period; and especially so as to prevent the loss of overpaid rents; and that for this purpose I think the legislature might fairly be asked to take action in certain directions, which I will endeavour to indicate at the end of my observations. I also consider that some of the existing forms of mining leases in this country are in many respects out of date, and contain provisions which are unsuitable to the times, and which I believe could not be, if they were attempted to be, enforced in practice. I can only suppose that they are retained in the same way in which we still stick to the old Cheshire measure in dealing with coal mines

in Lancashire, though that mode of measurement has for many years been illegal.

Sliding Scales.

I have also been for many years an advocate for the adoption of the sliding scale system of computing royalties in this country; but have been assured by persons older than myself that it had been tried in former times, and failed partly on account of the disfavour with which it was viewed by lessees when prices were "sliding upwards," and partly on account of the numerous disputes it gave rise to. Possibly the system has been improved, for I have received particulars of satisfactory arrangements which have lately been made in various parts of the country for leases of mines at royalties varying according to a sliding scale. What, however, I protest against is unjustifiable interference with contract, and anything approaching confiscation. I know that Mr. Percy does not advocate confiscation directly, nor does he, I believe, intend to advocate it indirectly after the humourous fashion of Henry George, when he said, "It is "not necessary to confiscate land," but let us "appropriate "rent by taxation."

Confiscation of Mines would not Benefit Lessees.

It will have been noted, however, that one gentleman, writing to the *Manchester Guardian* in reference to Mr. Percy's paper, expresses the hope that this Society will advocate what he calls "resumption by the State of the "nation's right in all minerals beneath the surface!" I have not got to argue with the writer of that letter; but I will point out what is undeniably the case, that confiscation of mines by the State would not bring much direct advantage to mining lessees, even presuming that the present lessees, who could only make a title to the mines through their lessors, were not despoiled simultaneously. The State

would be bound, as in the case of Government contracts, to deal with the highest solvent bidder; and the royalties would go to the Government instead of the lessor. Even assuming that such royalties were less in the first instance than the royalties charged by private owners, they would not long continue so. The original holders of concessions would sublet to new parties at higher royalties, representing the full market rental value of the mines, or would sell their concessions, the interest on the purchase money being equivalent to royalties. Such courses are often adopted in the case of foreign mines held from the State, and consequently (as Sir Lowthian Bell clearly points out) the supposition that confiscation by the State would ultimately prove to be for the advantage of the lessee, is altogether illusory. As regards the advantage which might be gained by the general taxpayer, I believe it will be a long time before a majority of Englishmen will allow that any such gain would be sufficient compensation for the loss of our national morality!

Proposed Parliamentary Enquiry.

It will have been observed that steps are being taken to obtain a Parliamentary enquiry into the subject of mine rents and royalties. This proposal may at first sight be looked on by mine owners with disfavour, as it may appear to suggest that there is something unfair in the present system of charging royalties; but on consideration it will probably be found that there is no need for them to fear it, if it is made by Royal Commission, and the scope is sufficiently extensive to include an enquiry, not only into the rents and royalties, but also into the profits made by lessees during the course of existing leases and also into the causes for the present unremunerative position of our mining undertakings and as to the proper means which should be adopted with the view of improvement. If such an enquiry

were made, it might, for instance, be found that the difficulties existing in some mining companies arise, not so much from the royalties, as from the fact that the original lessees have taken out of the undertakings at the commencement of the leases enormous sums for their interests in such leases, which sums, if spread over the whole terms of the leases in the shape of profits, would have put altogether a different complexion on the balance sheets. It may also be found that some account should be taken of the fact that many of our manufacturing industries do not look sufficiently ahead, and are, therefore, not creating that demand which would arise if they kept pace with the results of foreign technical education and enterprise.

This supposition does not apply to all our manufacturing industries. The other day there appeared in the *Manchester Guardian* the report of "Messrs. Charles Cammell and Company, Limited," (Cyclops Steel and Iron Works, Sheffield,) from which it appears that the net profits for the year 1887 were £132,821. A dividend of 7½ per cent. on the ordinary shares was declared, being at the same rate as the previous year, leaving a sum to be added to reserve and a further sum to be carried forward to next year, amounting together to almost twice the amount of the sum appropriated for dividend. The chairman stated (and the managing director confirmed his statement) that trade was improving, and there was every prospect of the ensuing year's operations being similarly successful. They turned out about 1,000 tons of rails every day, and employed 8,000 to 10,000 hands; they had five places going, including the colliery, thus having under their charge an immense amount of labour which must be a great benefit to the neighbourhood. When they considered all that and remembered that they had at their bankers a comfortable balance, he thought he was justified in using

the word "splendid." No one will deny that he had a right to do so, and I am given to understand that if other concerns in the country kept moving with the times in the same way as Messrs. Charles Cammel & Co., Limited, we should have much less depression and hear much less of the cry for Parliamentary assistance which is so common now-a-days.

Suggestions for Legislation.

In conclusion I will say that, even admitting Mr. Percy's view that "something must be done," it is not yet necessary for us to violate first principles of political economy; for something of practical use may be done in the following directions, viz.:—

Removal of disability of Trustees to revise leases and grant renewals.

1st.—Trustees or quasi-trustees should be distinctly empowered in all cases, without necessarily going to the Court, to revise the terms of existing mining leases and to grant extensions of such leases with power in granting extensions to give the lessees credit for any sum they may have overpaid through fixed rents in excess of the measurement rents or royalties, and also with power, in altering existing leases, or granting new leases, to adopt the sliding scale system of reservation of royalties. It has been suggested to me that it might not yet be too late to approach Lord Herschell with the view of getting him to introduce some such provision into the Bill which he has brought into the House of Lords this session, "To amend the law relating to the duties and liability of Trustees." Such a provision, if authorized by law, would not only enable many trustees who are willing, but unable to make satisfactory arrangements with their lessees to do so, but would also act as an intimation to mine owners not under disability, that the legislature recognizes the propriety and desirability of such arrangements being

come to where the terms of leases have been found to have become unduly burdensome.

To obviate necessity for Reservation of Heavy Fixed Rents.

2nd.—The necessity for the reservation of heavy fixed rents (with the objectionable results of "overpaid rents") would be obviated if Parliament would authorize a somewhat stricter construction being put upon covenants for working mines. In the United States it does not appear to be usual to reserve fixed rents; but the ordinary form of lease contains covenants by the lessee to enter and work the mine in manner necessary to good and economical mining so as to take out the greatest amount of ore possible *with due regard to the development and preservation of the same as a workable mine*, and to the special covenants contained in the lease, and to work the mine steadily and continuously from the date of the lease. If the performance of covenants such as these could be specifically enforced in this country, there is little doubt that the system of reserving heavy certain rents would gradually disappear.

For Regulation of Wayleaves.

3rd.—Some legislative provision seems desirable, with respect to the regulation of wayleaves (particularly if, as seems likely, owing to the effect of the settled Land Act and other causes, properties become more divided in this country than they have hitherto been), to prevent mining adventurers from being unduly hampered, and to avoid minerals being lost to the nation through the perversity of individuals. It seems to me that if three-fourths in number and value of the owners in any specified mining district, which should naturally be worked by the same undertaking, are willing to let their mines upon fair terms, but the minority of the owners refuse to accept the same terms, the lessees may fairly ask to be entitled to necessary wayleaves through the mines of the

minority for the purpose of working the mines of the majority, of course making reasonable compensation for the use of the wayleaves and any damage caused through such use.

CONCLUSION.

It will be seen that the legislation that I advocate has nothing about it which can be termed *heroic;* but I believe that it is practical and practicable; and I venture to think that, if such legislation is speedily effected, although Mr. Percy's "promised land" may not have been reached, undoubted relief to mining lessees will result and the time and labour which has been expended on the subject of "Mine Rents and Royalties" under the auspices of this Society will not have been spent in vain.

ON MINE RENTS AND ROYALTIES.

BY MR. JOSEPH S. MARTIN, F.G.S.

I think it can hardly be claimed that speculators or investors in bogus or inflated companies deserve sympathy from the public to such an extent that the lawful ownership of minerals should be confiscated for their benefit if they have made a bad bargain. Jealousy and greed have much to do with these large rents, &c. I am informed of the following case: a colliery proprietor whose workings approached some unlet coal, thought of taking it, as he was in a position to work it with advantage with some which he had already secured. But it coming to the knowledge of a neighbour that he was in treaty for it, the neighbour went behind his back and secured it, at terms which are now deemed onerous inasmuch as he has not been able to get any of the coal, and a dead rent of some £600 per annum has had to be paid for neary 20 years. Cases of this kind

are so numerous in the coal trade that I fully believe the lessors are the smaller delinquents. Similar instances may be found in every commercial centre, whether dealing with coal, ironstone, farming, cotton spinning, engineering, &c. Mr. Percy says we are unfairly circumstanced. I may say that in Germany the difficulties far exceed ours, the distance lying between their coal and iron ore, and its variable quality, being such that I much doubt whether with some of our present methods of working we would get on at all, although, of course, the subject would be grappled with by us if the need arose, just as it has been by them. Their export difficulties are greater, owing to the long railway carriage, and as regards mining legislation, it is even more stringent than the sometimes much abused home laws. As regards the royalty burdens of this country, it is with Germany and other countries, I believe, much the same, at least if it is not so yet, owing to their being space still unoccupied for new comers, it is rapidly becoming so. In Germany, for example, the Crown is the mineral proprietor, and the concessions are granted with reservations, on the condition of two per cent. royalty being paid. This, however, allows of transfer by sale or other agreement, always subject to the two per cent. to the Crown. This was originally imposed with a view of merely covering the cost of inspection, but is now retained to help other things. In most cases sufficient capital is provided to purchase the coalfields, and in some cases £20,000 to £30,000 is paid for them with all risks as to faults, sinking, &c. I have known a capital of £180,000 expended without coal having been reached, and also several smaller capitals of £80,000 and £100,000 lost through sinking difficulties. In Germany also a colliery proprietor, while subject to the Employers' Liability Act,

has also to pay 20 to 50 per cent. on the compulsory sick fund contributions of the workmen, the amounts being fixed from time to time as the funds require. This is a burden not imposed in this country, although to some extent voluntarily undertaken. In Spain where the relations of the Crown as to minerals are, I believe, similar, royalties are now not unfrequently imposed by the holders of concessions, where others are desirous of working them. I was informed recently by the general manager of large iron works extensively interested in iron ore working in Spain, that as much as 8d. per ton is being levied there. In the Forest of Dean which Mr. Percy refers to, and where 2d. to 6d. royalty is paid to the Crown on coal, I have been informed of a case where, through sub-letting, the party working it was paying 2s. to 2s. 4d. per ton. Can such arrangements be prevented?

IRISH MINE RENTS.

By Mr. Joseph W. C. Meadows.

Although the quantity of coal in Ireland is comparatively little, I may be permitted to refer to it in your present discussion. In the Leinster and Slievardagh districts which are our chief Irish coalfields; the seams, with one single exception, are thin, consisting of Anthracite coal and culm varying from eighteen inches to two feet in thickness.

For upwards of the last thirty years over which my knowledge of these districts extends, the royalties charged by the landlords have been from one-eighth to one-twelfth of the gross sales, and as a rule fixed minimum rents are stipulated for in the mining leases.

In the Slievardagh district, for a surface area of about twelve square miles of thin anthracite, chiefly culm, as many as ten landlords had to be reckoned with, and a comparison of the sums received by them for mine rents and royalties for the last fifty years, in contrast with the returns realised by those whose capital developed and worked the mines, would be instructive.

The sub-division of freehold estates among the occupying tenants which is now going on in Ireland under the Land Purchase Acts, increases the difficulties of developing any minerals that may hereafter be found under holdings so acquired in absolute freehold. It is much to be desired that in any future legislation in the same direction, or in the granting of further monies for the creation of peasant proprietorship in Ireland, all minerals and royalties should be reserved to the Crown with all necessary rights of working. In the absence of their being so reserved the difficulties of dealing with the subject are too obvious to need any comment.

ON FOREIGN AND HOME MINE RENTS AND ROYALTIES.

By Mr. William Clifford, M.E.

In speaking of the resources and ability of other countries to compete with us in our large industrial enterprises, it is essential that the statements and figures should be accurate, upon which our deductions are based. No comparison is fair in considering the question of mine rents and royalties which does not place side by side the royalties payable in this country and those other countries quoted for comparison.

It is also necessary, in arriving at a proper conclusion, to take into account the varying circumstances of cost of production, the nearness or remoteness of the market, &c. If we see that coal royalties abroad are often double and treble our own, and wages higher, and in some cases the selling price less, we must come to the conclusion that other causes are operating to bring about the state of things now existing in England.

I have observed that those Englishmen (and some of them practical colliery men), holding advanced views on the subject of mineral royalties, who have visited the United States have on their return without variation lost sight of the subject altogether in their clever, interesting and otherwise accurate accounts of coal mining as carried on there. It is a matter of surprise that a gentleman so well informed as Mr. Percy, and with his command of reliable information, should have used for the purposes of comparison the astounding statements contained in the "spread eagle" speeches of Mr. Andrew Carnegie.

To repeat the statement that coal was delivered into the mills at from 2s. 6d. to 3s. per ton, would in Pittsburgh produce a laugh.

At the time coal was displaced by natural gas, the prices delivered into mills, glass works, &c., were as under:—

	Per ton of 2000 lbs. s.	d.
Screened over 1½in. screen (large lumps) ...$ 1·45	= 6	0½
Do. ¾in. do. (small lumps) ..$ 1·35	= 5	7½
Unscreened .....$ 1·20	= 5	0

The prices at the pits would be about 1s. 4d. less.

The present prices paid to the collier for getting coal (which like the royalty are on the actual clean coal weighed into railway trucks by a kind of "Billy Fairplay"), are as under:—

	Per ton of 2000 lbs.		
	Cents.	s.	d.
Over 1½in. screen (large lump)	79 =	3	3½
Do. ¾in. do. (small lump)	65 =	2	8½
Unscreened	50 =	2	6

I have thought it necessary to give these matters at length in correcting a statement of a gentleman who has such exceptional opportunities of informing himself on these matters. To show that it is not simply assertion against assertion, I append official circular settling the prices (of course, supposing the colliers consent to it) for the year ending April 30th, 1889:—

"OFFICIAL CIRCULAR

"ON

"Resolution and Scale of Prices adopted at the Joint Conference "of Miners and Operators of Indiana, Ohio, and Western Pennsyl- "vania, held in the Lafayette Hall, Pittsburgh, Pa., February 7th "to 9th, 1888.

"*Resolved:* That the scale prices from May 1st, 1888, to Novem- "ber 1st, 1888, shall be five cents per ton above the scale base "adopted by this Convention, and ten cents per ton above scale base "from November 1st, 1888, to May 1st, 1889. The prices for the "ensuing year shall be as follows:—

	Scale Base.	May 1st, to Nov. 1st, 1888.	Nov. 1st, 1888, to May 1st, 1889.
"Hocking	60 ..	65 ..	70
"Pittsburgh district.....	69 ..	74 ..	79
"Reynoldsville and Fairmount	65 ..	70 ..	75
"Indiana, block	80 ..	85 ..	90
"Indiana, bituminous	65 ..	70 ..	75

"Very truly yours,

"A. DEMPSTER, PRESIDENT.

"CHRIS. EVANS, SECRETARY."

From this document it will be seen that there will be a reduction of 5 cents for the first half and present prices for

getting coal (which does not include hauling or putting or dead work) for the second half of the coming year.

The present selling prices (March 20th, 1888,) of coal loaded into railway waggons at the collieries in the neighbourhood of Pittsburgh is as below :—

	Per ton of 2000lbs. s.	d.
Screened over 1¼in. screen (Large lump)	$ 1·10=4	5
Do. ¾in. do. (small lump) 90c. to $1·10=	4	0
Unscreened .....75 to 80 cents=	3	3

Carriage to Pittsburgh 1s. 6d. about.

Royalty now payable where collieries are worked under lease in this coal-field, 6¼d. to 9¼d. per ton.

In speaking of natural gas, Mr. Percy again fails to be quite accurate. Like some of our colliery owners in the good times of 1871 and 1872, the Pittsburgh mill owners fancied they had entered upon a new era when gas was discovered in such abundance four or five years ago, and notwithstanding the predictions of eminent Geologists like Mr. Lesley, that natural gas would probably be a thing of the past in the lifetime of some of those who listened to him ; wells were drilled in all directions, companies were organised to supply districts, towns, and villages, in Alleghany, Beaver, and Washington counties ; and also to carry the new fuel to the ironmaking districts in the Mahouing and Shenango Valleys, about Newcastle, Pennsylvania, and Youngstown, Ohio, 60 miles away. The enormous pressure at the wells at first admitted of the use of small main pipes, 6 to 8 in. diameter, giving a plentiful supply. The pipes now used to deliver about the same volume are from 20 to 30 inches in diameter, the diminished pressure at the wells making diminished friction in the mains a condition of constant supply.

The quantity passing through the 12 inch main (60 miles long) to Youngstown, Ohio, has fallen off to such an extent

that some coal is now being used there. With the continued falling pressure at the wells, they must return to the use of coal in the large rolling mills and blast furnaces in that town, or duplicate the pipe line, this last, remarks a shrewd Pittsburg man, requires "dollars and some courage, "and, I will add, a little foolishness too. All natural gas "stocks are a long way down below par (with one "exception)." That may be taken as a good gauge of public opinion in Pittsburg.

The present volumes are being kept up by continual drilling of fresh wells in gas belts distant from Pittsburg, and no fresh belts have recently been discovered.

Five million tons of coal have been displaced by natural gas in Pittsburg and the surrounding district. Last year, the product of the Pittsburg coal-field was 500,000 tons more than in any previous year. Collieries which were without railway or river connections, closed when the demand from the mills and glass-works ceased. Those remaining have pushed out into the markets of Lake Erie, Canada, and the north-west, and to such lake shore towns as Toledo, where the discovery of natural gas, a few years ago, produced an excitement which died away with the gas supply.

These are facts, and we feel justified in expecting Mr. Percy to know them, when making comparisons on which to found arguments.

The colliery owners about Pittsburg are described as now engaged in a race of cutting prices and increasing output to cheapen production. They are rapidly working out the available coal within a reasonable distance of the city and above "water line," with the failing supply of natural gas, which will very soon be sensibly felt, Pittsburg may receive a most serious check instead of acceleration in the race

for industrial supremacy, predicted for her by Mr. Andrew Carnegie.

It was about the commencement of the last century that the owners of land in England generally, began to find out that the coal under it had a value, which was probably unknown at the time the lands were acquired by grant or by purchase. This value has continued to increase until the present day.

The same thing happened in North America, when the original settlers acquired lands, or when their immediate descendants sold them, the coal and iron underlying them were entirely lost sight of.

Whatever we may have to say of the considerations in respect of which persons received lands in England, afterwards found to contain valuable seams of coal, the conditions of acquisition will bear favourable comparison with the methods pursued by settlers in the United States. Sometimes they were taken by force, and a patent obtained to confirm the right of the strongest. In other cases the fairer minded frontiers-man purchased them from the "noble savage," and paid for them in that kind of currency which made the bargain irresistable to an Indian—barrels of whiskey, guns and ammunition, knives, and hatchets. The contents of a wagon often covered the purchase of many square miles.

In the many grants, royal and republican, referring to vast tracts extending over degrees of latitude and longitude, no reservation of minerals has ever been mentioned, and no American statesman or lawyer has ever raised the question. He would be considered in America a bold and a dangerous man who should attempt, at this time of day, to legislate away the enormous "unearned increment" in coal lands.

Two centuries here, and nearly one century in the State of Pennsylvania, have been required to develop the value of coal seams. A few years only, and in some cases months, have wit-

nessed the same transformation in parts of Virginia, Kentucky, and Tennessee. Land, underlaid with coal and covered with good timber, is to-day to be bought in the mountain regions in those States at as low as 50 cents (2s.) per acre.

A few years ago a syndicate bought enormous tracts of this kind of land with three seams of coal outcropping in the hill-sides. The bulk of the purchase was as low as 2s. per acre. The whole was immediately re-sold to a company at £1 per acre. In 1884 this company was desirous of leasing one of the seams under a part of their huge domain at the *modest* royalty of 7½d. per ton on the 10 feet thick of coal usually taken out. A railway, 75 miles long, had been built into the district with English bondholders' money, and by the same means the coal was carried to market from an adjacent colliery already in operation, 300 miles for 5s. 3d. per ton.

I believe Mr. Percy's figures for royalty in Yorkshire and the Midlands are greatly in excess of the amounts paid. It is not enough to quote the prices paid in 1871 and 1872. One notable case, where the Silkstone coal was then leased at £560 an acre, the pits were sunk, and the owner failed as soon as they were bottomed. The coal was leased the other day at £130 (I am informed) per acre.

In the North Derbyshire district I know only one Silkstone colliery at present at work where the royalty is 6d. per ton, and in that case the landlord only gets 3½d.: it is worked by a sub-lessee.

Below will be found the royalties received by the largest owner of minerals in the county:—

Top Hard Seam.—Highest, £150; lowest, £88 per acre. Greater part let at £90; average produce, 6,500 tons per acre; 4·39 pence per ton royalty.

Deep Soft Seam.—Highest, £70 per acre. Yields 6,000 tons per acre; 2·6 pence per ton royalty.

TUPTON SEAM.—Highest, £50; lowest, £44; say £48 average. Yields 4,000 tons per acre; 2·5 pence per ton royalty.

BLACK SHALE, A SILKSTONE SEAM.—Highest, £100; lowest, £48; average, say £80. Yields 5,000 tons per acre; 3·84 pence per ton royalty.

A hearty vote of thanks to the contributors of the papers was proposed and carried unanimously.

ASHWORTH'S PATENT HEPPLEWHITE-GRAY SAFETY LAMP.

BY MR. JAMES ASHWORTH.

In the course of the safety lamp experiments made by Mr. William Smethurst and myself, at Brynn, near Wigan, in 1878-9, a full report of which is printed in your Transactions, Vol. XV., Part VI., we tested a lamp of the Eloin type called the Gray, and reported that it was a safe lamp, but heavy and furnished with an insufficient outlet for the products of combustion.

To this statement the inventor, Mr. Thomas Gray, of Taibach, Glamorgan, took great exception in a letter to the *Colliery Guardian*, of the 22nd April, 1886, and I replied privately to explain that the Gray was heavy as compared with the shielded lamps in use in 1878, but *not* as compared with the shielded lamps of 1886, and that the insufficient outlet still existed.

Mr. Gray then forwarded me one of his lamps to test and alter in any way I might desire, and as it had certain distinctive points to recommend it I felt encouraged to try to make a successful lamp especially adapted for gas testing purposes. In this opinion, I do not appear to have been

singular for the late Mines Accidents Commissioners drew particular attention to the Gray, and one of them brought out a modification called the Clifton, the practical failings of which were such that it never passed out of the experimental stage. This did not deter the Commissioners from placing it in a most prominent position in their final report coupled with a list of its failings and also some remedial suggestions.

The first defect was the danger of the glass cracking from the heat produced by gas burning at the cylindrical strip of gauze immediately under it, and they suggested that a horizontal gauze ring should be introduced to extend from the neck of the oil vessel to the underside of the glass cylinder, covered by a short conical metal shield similiar to, but more open than that surrounding the wick tube of the Eloin. A thin cylindrical glass of a refractory kind placed loosely within the ordinary cylindrical glass was also proposed.

Another great defect was the loose cover over the outlet gauze which was not secured to the frame, and therefore afforded no real protection to this gauze which was of too small area, and lastly, no means were provided for shutting out inflammable gas.

This long list of black marks had only one redeeming point, viz.: that the Gray was better suited for the purpose of searching for fire damp near the roof of a working place than the Marsaut or the Mueseler.

My first alterations were directed towards adapting the novel parts of my lamps Nos. 2 and 4 of the Mines Accident Report to the Gray, and to do this I took out the horizontal gauze disc and the tin cones from within the cylindrical shield or chimney, and replaced the former by a slightly conical gauze fitted at the base with copper rings flanged to clip the top of the glass, and the latter with a conical outlet

permanently attached to the top of the cylindrical shield, and lastly, the loose cover was made a fixture.

These improvements with the addition of a truncated conical glass and a flat wick tube constituted the main points of my improved Gray as exhibited by me at the Newcastle-on-Tyne Royal Mining Engineering and Industrial Exhibition, and for which, and my other lamps the jury awarded me the only medal for "Improvements in Safety Lamps."

This improved Gray with the additions that I have patented, and which are described below, is the lamp I have now the pleasure of introducing to your notice and criticism at the invitation of your Jubilee President, Mr. Dickinson. "The shut off" is a circular plate which revolves or screws on the top frame of the lamp and closes all the inlet holes at once, and when put into action immediately extinguishes all flame within the lamp. I may here remark that no mechanical "shut off" is really required for this lamp, as all flame may be completely extinguished by turning the lamp upside down and without spilling any oil.

The bottom gauze or sieve ring originally had three or four rectangular openings through its cylindrical side, covered by gauze, and was rendered very weak by the cutting away of so much metal, but it is now made very strong with a solid cylindrical side, in which a groove is cut in the outer circumference, and holes bored through from the bottom of the groove. The outer circumference is covered by gauze, thus forming an annular space between the gauze and the holes, the useful purpose of which is to gain a larger area of gauze for the inlet air, without increasing the size of the ring, and to obtain a better protection for the glass, and also to effect the same object that Professor Clifton obtained with a double gauze over the inlet and a copper cone, and finally to make the extinction

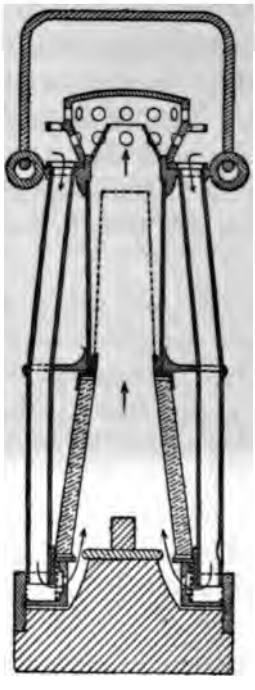
of the wick flame and gas more certain when the latter explodes within the lamp (that is when the gas testing arrangement is not in use).

THE GAS TESTING ARRANGEMENT.—The introduction of shielded lamps having become compulsory, the old and favourite naked Davy lamp is no longer applicable to the necessities of the day, and I have devoted many months to experimental research to find out a method that would equal and if possible surpass the Davy in accuracy and be very simple in its details.

To attain this object I cut one or more holes near the base of one or more of the inlet tubes, or through the lamp frame of the Gray type of lamp, and either above or below the glass in lamps of the Clanny, Mueseler, or Marsaut types, such holes being covered by movable shutters, which regulate the admission of fresh air to the wick flame, independently of the ordinary course of the ventilating current of air within the lamp. Consequently, shield lamps, which are properly constructed to take the whole of their air supply from the top or near the top of the shield, can be used to make accurate tests of fire-damp with very little risk of the wick flame becoming extinguished by an excess of gas when this arrangement is added to them, but the tests are *not so accurate or quickly made with these lamps* as with the Gray type.

The fireman or official controls the whole lamp with one hand only, when making a test for fire-damp using the thumb and forefinger to regulate the admission of fresh air where the tube slides are used, and one finger or thumb where the other arrangements are adopted. Thus, when the fireman commences to test, he pushes up one or both the shutters and raises his lamp in the ordinary way but without lowering the wick flame, until the spiring up or elongation of the flame indicates the

presence of gas, or the lamp reaches the highest part of the mine without an indication.



ASHWORTH'S PATENT
NEPPLEWHITE-GRAY DEPUTY LAMP.

At this point, the holes are gradually closed, and any small percentage of gas is present it will be indicated as before described. With deflector or double shielded safety lamps, such as Ashworth Mueseler (B), which I hold in my hand, a sliding ring is fitted either horizontally or vertically at the base of the shield, and when the fireman or deputy is testing for gas, he first *closes* the holes, to compel the whole of the inlet air to enter near the top of the shield, and as soon as the wick-flame indicates gas, he *opens* the shutter to save the wick-flame from extinction by an excess of gas. It has always been a rule to lower the

wick-flame of the Davy or Clanny lamp to obtain accurate and close tests, but in this case the finest tests are made with a normal or full-sized flame, and, as some indication of the relative values of various lamps, I append particulars of a few notable tests made by Mr. Hepplewhite, which show the value of this lamp as a means of detecting gas when compared with lamps in ordinary use.

I.—"A small quantity of gas was found issuing out of a "break at the gate lip which was sufficiently strong to put "my lamp out with the shutter down, and yet neither the "Davy, Clanny, or Marsaut would show one particle of gas."

II.—"A feeder of gas was freely issuing from a break in "a gate road, a cloth had been erected the whole of the "width of the gate and to within about a foot of the roof "with a very fair amount of air passing over. I could hold "the lamp (A.H.G.) any length of time in the mixture and "it would continue to burn full of flame when the shutter "was open, but with the shutter closed the light could not "be recovered. A Clanny, a Marsaut, and a Mueseler "tested in a similar way were all extinguished, but the "Davy was not extinguished."

III.—"I have tested with the Marsaut and Mueseler "lamps to compare them with the Ashworth-Hepplewhite-"Gray lamp, and I find that they will not show gas until "raised nine inches higher."

IV.—"I have have frequently found gas with the "Ashworth-Hepplewhite-Gray lamp when no other lamp "would show a trace of it."

Mr. R. B. Mawson, in moving a vote of thanks to Mr. Ashworth, said the question of safety lamps was one of great importance to all mining engineers, and they could not go too deeply into the matter of which was the best lamp. They had a great many before them at present, but they might have something still further in that direction.

PEARSON'S PATENT "ECLIPSE" MINERS' SAFETY LAMP.

By Mr. J. E. Moore.

I have much pleasure in introducing to your notice Pearson's Patent "Eclipse" Miners' Safety Lamp. Mr. J. S. Burrows, in his paper read before this Society, on the 3rd March, 1885, remarked—"The best lamp known, properly secured; provided, cleaned, and maintained by the owners; is absolutely necessary for the safe working of our coal mines."

I have the greatest confidence in stating that I believe you have before you to-day the very best miners' oil safety lamp that has ever been introduced to the public, and it is difficult to see how it is to be improved upon. Apart altogether from the automatic action of the lamp, which is its special feature, I can safely say it is fully equal to the best lamp known of its kind, and, if anything, we believe the light to be even better. The miner has, therefore, in his hands, to start with, a lamp fully equal to the best miners' oil lamp made. In addition to this, by an ingenious arrangement, before it would be possible for an explosion to take place, no matter what quantity of inflammable gas the lamp may be passing through, the light is extinguished and the air-feed cut off simultaneously; so that any blue flame which might linger in the gauze of the lamp is instantly put out through the air being excluded.

The automatic action of the lamp in extinguishing the light is extremely simple. Right across the wick, and parallel with it, a spring is fixed, to which is attached a copper extinguisher, which lies well below the flame when the spring is at tension. From one side of the wick two upright rods ascend into the funnel of the lamp, one being rather longer than the other. The smaller rod is attached

to the spring, and when the spring is at tension the smaller rod is brought right up to the longer one, and is fastened to it by a fusible metal band, which passes round the forks at the extreme ends of the rods, and which can be made to break at any given temperature.

Level with the air-feed is a kind of lock, formed of two small bars, about an inch apart, fixed at right angles to the smaller of the two rods just alluded to, and parallel with the air-feed. When the extinguisher spring is at tension, the lower of the two bars is level with the air-feed, and supports a lever which passes through a hole in the gauze and keeps open the air-feed. This it does by fixing itself in a slot which is so constructed that, when the lever lies in it, the air apertures in the shut-off are exactly over the air apertures in the lamp, and, while so fixed, a spring in the shut-off is at tension. Immediately the fusible band breaks, the wick flame is extinguished, and the lever being pressed by the higher bar of the small rod, which has now fallen on it, is raised out of its slot, and the spring in the shut-off being brought into action, all air is immediately excluded, and any flame, of whatever nature, which might linger after the extinguisher had fallen on the wick, must by this additional safeguard, be put out.

As the automatic action for the shut-off is in the strongest part of the lamp no jambs can affect it, and there is nothing in the nature of the action which could cause any current to drive the flame through the gauze. As the shut-off is worked by an independent wire spring, no dirt or grit can hinder its action.

By using a fusible band, which would only break at a very high temperature, the lamp can be adapted to firemens' use, or, if needful, it can be set so that the band does not break at all, in which case it answers all the purposes of the best ordinary safety lamp.

You have on the table one of the lamps in question, which we are quite willing to have put to any test. We have also brought an experimenting apparatus, so that you may be able to see here whether the lamp fully bears out the high character we have given it, and which has also already been given to it by high authorities elsewhere.

The inventor of the lamp, Mr. Pearson, is present and will, I am sure, be only too glad to give any further explanation of the lamp that may be needed.

Mr. WINSTANLEY asked how long it took to take the lamp to pieces.

Mr. PEARSON said they had not really tested it, but they could put it together as soon as a Johnson and Clapham's lamp. It was so constructed as to prevent the possibility of any accident taking place.

Mr. MOORE said whilst the Mueseler would go out of itself the Eclipse would only go out automatically.

The PRESIDENT said there was a lamp in use in Monmouthshire in which the light was put out by means of a small piece of tin.

Mr. HALL: What about the cost of this lamp.

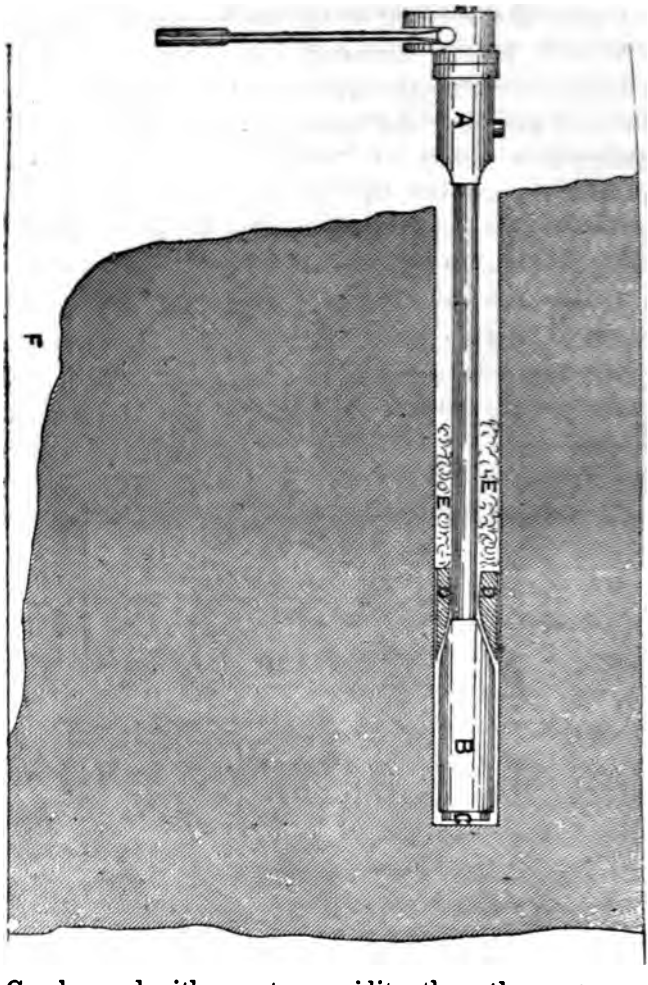
Mr. PEARSON: It will be about the same as Johnson and Clapham's. I shall be glad to put it to any test after the meeting.

CUNLIFFE'S PATENT HYDRAULIC COAL-GETTER.

BY MR. MAUNSELL MERCIER, M.E.

I will, with your permission, assume that we are all of one mind as to the desirableness of substituting a mechanical method of coal-getting for gunpowder or other explosives in the working and winning of gaseous and dusty mines, provided such mechanical appliance will perform the work

in an efficient and economical manner. And I will further assume that we are agreed as to the danger which must of necessity accompany the use of any explosive, and, on the other hand, that with mechanical methods this danger is completely overcome. I have every confidence in saying that Cunliffe's Patent Hydraulic Coal-getter is capable of working almost, if not all, the mines in the English coal-field, whether worked on the pillar and stall or long wall system, and can be used with satisfaction in most mines in the roof or warrant The Cunliffe Patent Hydraulic Coal-getter applies the great power of hydraulics in a manner which is more perfect in principle and mode of application than any previous invention, and there is practically no limit to the power it can apply at the back of the hole to bodily pull and break off the coal. Unlike other machines for the getting of coal, it is not a wedge, and does not exert its force to break or wedge the coal down vertically, but in a horizontal direction. The machine you have before you to-day will exert a pressure of some 25 tons by one man pumping, and stronger machines are in course of manufacture, which will enable one man to put on a pressure of 30 tons and upwards. The machine is so simple to operate that any collier can work it after seeing it once used. After the hole has been drilled 3¼in. diameter, the working barrel (B) is placed in, and well to the back of the hole, the two semi-circular keys (DD) are then tightly driven in, when the head (A) may be screwed on, and the pump actuated. In most cases the charge of water in the head (A) will be more than sufficient, and the whole operation (after the hole is drilled) does not exceed, at the outside, five minutes. The machine is of a very portable form, and can easily by carried by one man from place to place, the whole weight not exceeding 40lbs. The advantage claimed for Cunliffe's Patent Hydraulic Coal-getter are as follows:—



CUNLIFFE'S COAL-GETTING MACHINE.

1. Can be used with greater rapidity than the water cartridge. 2. No loss of work caused to the collier by missed shots, and therefore give a more regular output. 3. Is more economical than an explosive, the first cost of the machine, with a slight addition for repairs, being the only expense, giving a clear gain on each shot of the cost of the explosive and fuse. 4. No noxious gases or fumes being given off, it

is a great improvement to the sanitary state of the mine. 5. Gives a greatly increased percentage of round coal. 6. Does not require the coal to be holed to as great a depth as with an explosive and therefore reduces the height of the balching to a minimum. 7. Can be used in the presence of gas with absolute safety. 8. No risk of injury to life or limb by shots going off whilst charging. 9. Does not require any powerful detonators, which are a source of great danger. 10. Can be used by the collier or any workman of average skill. 11. Are not liable to get out of repair. The cost of the machine (complete) is £14, but one head or pump can be used to several working barrels, which greatly reduces the expense. For comparison of the costs of working we will compare the three systems in a mine similar to our Wigan Four Feet, raising three hundred tons per day, and worked on the long wall system. For three hundred tons per day we will assume seventy-two colliers are required, each man having one shot fired per shift—equal seventy-two shots per shift—and say two hundred and sixty working days equal 18,720 shots per annum. *Powder.*—We will take each shot to cost 4d., and 18,720 shots at 4d.—equal £312 expenditure per annum on 78,000 tons of coal, which is equal to ·96d. per ton. *Water Cartridge.*—We will take each shot to cost 6d., and 18,720 shots at 6d.—equal £468 expenditure per annum on 78,000 tons of coal, which is equal to 1·14d. per ton. *Cunliffe's Hydraulic Coal-getter.*—We will take one head and two machines at a first and only cost of £20 to be sufficient for six men. Seventy-two colliers will therefore require twelve sets of machines at £20—equal £240, or a saving in the first year of £72 over powder and £228 over the water cartridge. If we base our calculation on 20 per cent. on the outlay of capital, the cost each year for the Hydraulic Coal-getter will be £48, as against £312 and £468, and £48 for 78,000 tons of coal per annum—equal ·14d. per ton, against

·96d. and 1·44d. In these estimates I have made no allowance for the increased percentage of round coal, which will not be less than from 10 to 15 per cent., which will more than cover the cost of any extra labour in drilling larger holes.

Mr. HALL said if the invention would only carry out what was claimed for it, it would be very valuable.

The PRESIDENT said he understood that the coal getter was in use at Duxbury Park Colliery and Rosebridge, and that it differed somewhat from the old hydraulic process.

Mr. MERCIER said that was so.

The PRESIDENT: Several which have come under my notice have not been successful, but this appears to have considerable merit.

Mr. GRUNDY said that he had seen it in satisfactory use at Duxbury Park and thought there was considerable danger of the coal falling on the men whilst pumping if the gob was close to the face of the coal.

Mr. MERCIER said all danger could be obviated by the machine not being used until the gob was taken away.

The PRESIDENT said the coal would come down slowly and not suddenly as with powder.

Mr. MERCIER said in many cases where the coal was nearly ready for coming down, they unscrewed the head of the machine and took it out of the way of being damaged by the coal falling.

Mr. WINSTANLEY said there was a coal getter in use in South Staffordshire which was something like Mr. Cunliffe's.

Mr. MERCIER said there were several material points of difference.

Mr. ROBINSON: Is it possible for the ram to come out without bringing the coal?

Mr. MERCIER said that was not possible if the keys were properly driven home.

Mr. ROBINSON: Can you get the machine out without bringing the coal down, if it had failed to do its work?

Mr. MERCIER said in that case they would have to drill another hole, the same as they would have to do in case of a missed shot with powder.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XX. VOL. XIX. SESSION 1887-8.

The ORDINARY MEETING of the Members (and the last of the Session,) was held on Tuesday, June 5th, 1888, at the Rooms of the Manchester Literary and Philosophical Society, George Street.

The President, Mr. JOSEPH DICKINSON, F.G.S., in the Chair.

The following are the recent additions to the Library:—

Belfast—Natural History Society: Proceedings, 1874-75.—*From the Society.*

Cambridge: Annual Report of the Library Syndicate, 1888.

Chesterfield and Midland Counties' Institute of Engineers: Transactions, Part 7, Vol. XIV.; Parts 4 and 5, Vol. XVI.—*From the Institute.*

Cornwall—Royal Geological Society of: Transactions, Part 2, Vol. IX.—*From the Society.*

Edinburgh—Royal Physical Society: Proceedings, 1886-87.—*From the Society.*

——— Royal Society of: Proceedings for Sessions 1883-4, 1884-5, 1885-6, 1886-7.—*From the Society.*

Essex Naturalist: Nos. 1-6, Vol. II.—*From Essex Field Club.*

Hertfordshire Natural History Society and Field Club: Transactions, Part 8, Vol. IV.—*From the Society.*

Leeds—Philosophical and Literary Society: Annual Report, 1887-8.—*From the Society.*

Leicester—Literary and Philosophical Society: Transactions, Parts 6 and 7.—*From the Society.*

Liverpool—35th Annual Report of Free Public Library, Museum, &c. Two copies.

London—Quarterly Journal of Geological Society, Nos. 173-174; Vol. XLIV.—*From the Society.*

London.—Royal Society: Proceedings, Nos. 261-265, Vol. XLIII.; Nos. 266-267, Vol. XLIV.—*From the Society.*

——— Geologists' Association: Proceedings, Nos. 3-6, Vol. X.—*From the Association.*

——— Geological Magazine, Nos. 285-289.—*Purchased.*

——— Institute of Mechanical Engineers: Proceedings, No. 1, 1888.—*From the Institute.*

——— Year Book of Scientific Societies, 1888.—*Purchased.*

——— Report of British Association — Manchester Meeting, 1887.—*Presented by the Association.*

Manchester—Literary and Philosophical Society: Proceedings, Vol. X., 3rd Series, and Vols. XXV. and XXVI.—*From the Society.*

——— Field Naturalists' Society: Report for 1887.—*From the Society.*

Midland Institute of Mining Engineers: Transactions, Parts 93-95, Vol. XI.—*From the Institute.*

Mining Institute of Scotland: Transactions, Parts 8-9, Vol. IX.; Parts 1-2, Vol. X.—*From the Institute.*

Newcastle-upon-Tyne—North of England Institute of Mining Engineers: Transactions, Parts 2-4, Vol. XXXVII.—*From the Institute.*

Oxford—Radcliffe Library Catalogue, 1887.

South Wales Institute of Engineers: Proceedings, Nos. 5-6, Vol. XV.—*From the Institute.*

Warwickshire Naturalists' Field Club: Proceedings, 1887.—*From the Club.*

Yorkshire—Geological and Polytechnic Society of: Transactions, Part 3, Vol. IX., N. S.—*From the Society.*

Canada—Canadian Institute, Toronto: Proceedings, 1888, Vol. V., Fasc. 2; Annual Report, 1887.—*From the Institute.*

——— Montreal—Mc.Gill University: New Species of Fossil Sponges, Canada.—*From Sir J. W. Dawson.*

——— Montreal—Geological and Natural History Survey of Canada: Annual Report, Vol. II., 1886.—*From the Director of the Survey.*

——— Ottawa—Canadian Mining Review, Nos. 2-6, Vol. VI.

U.S.A.—7th Annual Report of the Californian State Mineralogist, 1887.

——— Cambridge—Harvard College, Museum of Comparative Zoology: Bulletin, Nos. 6-9, Vol. XIII.; Vols. XIV. and XV. Three Cruises of the "Blake," No. 1, Vol. XVI.—*From A. Agassiz.*

——— Indiana—Geological and Natural History Survey of: 15th Report, 1885-6.—*From John Collett.*

——— Minnesota—Geological and Natural History Survey of: 15th Annual Report, for year 1886; Bulletin, Nos. 2-4.—*From N. H. Winchell, State Geologist.*

——— New York—American Institute of Mining Engineers; Transactions, Index, Vols. I. to XV., in one vol.—*From the Institute.*

U.S.A.—Philadelphia—Franklin Institute: Journal, Nos. 746-750, Vol. CXXV.—*From the Institute.*

——— Philadelphia—Academy of Natural Sciences of: Proceedings, Part 2, April-August, 1887; Part 3, September-December, 1887.—*From the Academy.*

——— Philadelphia—Pennsylvania Geological Survey: Annual Report, 1886; Part 1, Coal Regions; Part 2, Oil and Gas Regions (with Atlas). Atlas of Western Middle Anthracite Field; Atlas of Bucks and Montgomery Counties.—*From the Board of Commissioners.*

——— Pottsville—Colliery Engineer, Nos. 6-11, Vol. VIII.

——— Washington—United States Geological Survey: Mineral Resources of United States, 1886.

——— Washington—U.S. Geological Survey: Coal. By Charles A. Ashburner.—*From the Author.*

India—Records of the Geological Survey of India, Vols. I. to XX., complete; Part 1, Vol. XXI.—*From the Governor-General of India in Council.*

Sydney, N.S.W.—Journal and Proceedings of the Royal Society of New South Wales for 1887, Vol. XXI.—*From the Society.*

Berlin—Deutsche Geologische Gesellschaft: Zeitschrift, Heft 3-4, Band XXXIX.—*From the Society.*

Brussels—Société Royale Malacologique de Belgique: Procès Verbal, 3rd July to 3rd December, 1887.—*From the Society.*

Buenos Ayres—Datos Annales del Comercio Exterior, No. 56, 1887.

Lausanne—Bulletin de la Société Vaudoise des Sciences Naturelles, No. 97, Vol. XXIII.—*From the Society.*

Paris—Revue de la Legislation des Mines, Jan.-Fev., Mars-Avril, Mai-Juin, 1888.—*Purchased.*

Pisa—Atti della Società Toscana di Scienze Naturali: Procès Verbaux, Vol. VI.—*From the Society.*

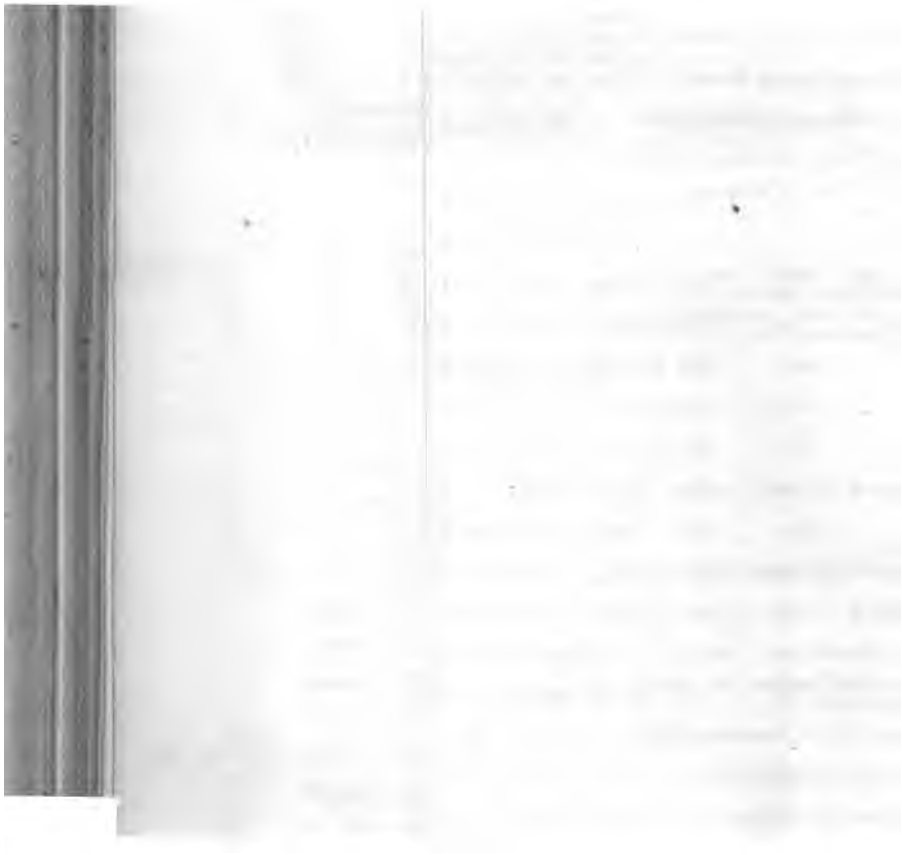
Roma—Atti della Reale Accademia dei Lincei: Fasc 10-13, Vol. III.; Fasc 1-8, Vol. IV.—*From the Academy.*

St. Petersburg—Académie Impériale des Sciences; Mémoires, Nos. 8-10, Tome XXXV.; Bulletin, No. 1, Tome XXXII.—*From the Academy.*

Stettin—Jahresbericht des Vereins für Erdkunde, 1887.—*From the Society.*

Wien—Bericht 13 Vereinsjahr verein der Geographen, 1887.—*From the Society.*

Pamphlet from Mr. Dickinson—"Uber den Einfluss der Luft-druck Schwankungen auf die Entwicklung von Schlagwettern."



THE SOUTH DURHAM SALT BED AND ASSOCIATED STRATA.

By Mr. W. J. Bird.

It is well known that the discovery of a workable bed of salt in the Tees district is of comparatively recent date, the first exploration being commenced by Messrs. Bolckow and Vaughan, who put down a boring at Middlesbro' in 1859. For a number of years no results followed from this discovery, but in 1874 Messrs. Bell Bros. reached the salt bed near Port Clarence by boring, and established brine wells and salt pans. Since that date operations have been gradually extended, and borings have been made over an extensive area, proving the extension of a continuous salt bed under a considerable district.

Papers descriptive of the salt bed have been read by Mr. T. Hugh Bell before the Cleveland Institute of Engineers, and more recently by Sir Lowthian Bell before the Institute of Civil Engineers. Since the publication of the latter paper the northern boundary of the salt field has been roughly determined by a series of borings extending from Hartlepool to Greatham.

The geological characteristics of the district have often given occasion for controversy, and our information on this point is almost entirely due to the knowledge of the boring sections. The whole area is thickly overlaid with a drift deposit, and hardly a single open section of the strata is to be seen.

The large map before you on the 6in. O.S. scale shows the district from Hartlepool to Middlesbro', and from Billingham to Eston. The smaller 1in. map shows a larger

IONS.

aliferous Beds, hydrite and Salt.		Magnesian Limestone.	Thickness of Salt.			Letter on Map.
			Pure.	Mixed.	Total.	
t. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	
7 0	364 0	38 0	....	....	....	A
...	....	184 0	....	....	....	B
8 10	714 4	55 8	....	....	....	C
8 7	522 0	878 0	....	....	....	D
...	....	....	....	....	....	V
9 9	....	....	68 6	14 3	82 9	E
4 0	....	....	112 9	4 0	116 9	F
6 6	....	....	115 4	....	115 4	G
7 0	....	....	101 6	9 6	111 0	H
3 0	....	....	90 6	28 8	119 2	I
9 7	....	....	95 4	27 6	122 10	S
5 0	....	....	104 6	....	104 6	T
5 2	....	....	94 9	8 6	103 3	U
0 6	....	....	87 10	5 8	93 6	R
5 9	821 9	179 3	. ..	9 0	9 0	N
9 6	1093 0	97 6	....	....	....	O
8 11	....	....	72 11	6 0	78 11	..
9 0	1261 0	94 0	89 5	27 0	116 5	K
6 0	....	.. .	65 0	12 0	77 0	J
4 10	1306 0	7 4	100 0	....	100 0	L
1 3	....	....	89 1	....	89 1	M
5 3	....	....	....	....	86 5	Q
8 8½	....	....	81 0	1 6	82 6	P

cularly directed to the five bore-holes A, B, C, D, and E, and the detailed boring sections are here given.

As all these borings were made by the Diamond Drill, and solid cores were obtained, their indications may be absolutely relied on.

(A.)

BORING AT WARREN CEMENT WORKS, HARTLEPOOL, 1888.

Strata.	Ft.	In.		Ft.	In.
Sand	22	0	....	22	0
Soft mud and peat	8	0	....	30	0
Red clay	18	0	..	48	0
Red pinnel with small cobbles	6	0	....	54	0
Dark pinnel and cobbles	18	0	....	72	0
Pinnel and cobbles	2	0	....	74	0
Dark pinnel and cobbles	19	0	....	93	0
Red clay	2	0	....	95	0
Soft limestone	1	0	....	96	0
Red clay	1	0	....	97	0
Hard rock	1	5	....	98	5
Anhydrite	265	7	....	364	0
Dark grey limestone	38	0	....	402	0

(B.)

BORING AT CELLULOSE WORKS, WEST HARTLEPOOL, 1888.

Strata.	Ft.	In.		Ft.	In.
Old well	37	0	....	37	0
Brown pinnel	13	0	....	50	0
Yellow clay	3	0	....	53	0
Yellowish white limestone (soft and porous)	135	0	....	188	0
Brown limestone	4	0	....	192	0
Dark shaley limestone, large-grained	33	0	....	225	0
Yellowish white porous limestone	12	0	....	237	0

area, and the geological map shows the situation of the district and its distance from the productive coal measures of the county.

The positions of most of the boreholes are marked by letters on the large map, and the lines of geological sections are drawn dotted in green.

It would occupy too much time and space to give all the boring sections, and I have selected 23 borings which have been correlated, and of which an abstract is given in Table I.

It will be remarked that the strata are classified as follow:—

1. Surface Deposits.
2. Upper Gypseous Marls.
3. Red Sandstones and Marls.
4. Lower Gypseous Marls.
5. Saliferous Beds (Anhydrite, Salt, &c.).
6. Magnesian Limestone.

1. The surface deposits consists of alluvial matter, and the Boulder Clay or Glacial Drift. They cover the entire district, and vary from 30 to 120 feet in thickness.

2. The Upper Gypseous Marls are, with the exception of a small strip west of Port Clarence, confined to the south side of the Tees, and thicken to the south and east. They are undoubtedly Triassic, and are generally considered "Keuper."

3. The Red Sandstones and Marls occupy a great thickness (up to 1,100 feet) near the Tees, but thin out to the north and west. Generally red sandstone predominates in the upper part, and red marl in the lower. These beds are also believed to be Triassic, and probably correspond to the "Bunter."

4. The Lower Gypseous Marls consists of a succession of Marls mostly red, and veined with Gypsum. They vary in thickness from 140 to 280 feet, and thin out westward.

These beds are by some geologists considered Triassic, whilst others class them as Upper Permian.

5. The Saliferous Beds have invariably at their top a bed of Anhydrite,* which serves as an excellent line of demarcation. This is usually succeeded by the so-called "rotten marl," to which is due the occasional collapse of brine-wells. Then succeeds the rock salt extending over considerable area, and varying in thickness up to a maximum of 119 feet, the greater portion of which exists in one or two comparatively pure beds, and the remainder consists of impure salt mixed with marl, gypsum, or *anhydrite*. To this succeeds the lower anhydrite, generally 30 or 40 feet thickness, but increased abnormally to 267 feet at Hartlepool. This lower anhydrite sometimes changes abruptly to the subjacent limestone, and sometimes is modified by slow graduations.

All geologists who maintain that the lower gypseous marls are upper Permian, of course, also include the Saliferous Beds in that series, whilst other authorities uphold the theory of their Triassic age.

The saliferous beds are 100 to 150 thick when including the salt bed. When, however, this is absent, their total thickness is diminished to from 30 to 60 feet. It may be remarked that possibly the Tees channel may mark a "wash-out" of the salt bed, a theory confirmed by the bore-holes marked N and O, but which requires further demonstration. The boundary of the salt bed on the south and east has not yet been found, but it has been determined on the north side, and your attention will be recalled to this part of our subject further on.

The magnesian limestone has invariably been found beneath the saliferous beds when these have been pierced.

* *Anhydrite*, is an amorphous sulphate of lime *without* water of crystallization.

Gypsum, a sulphate of lime *with* water of crystallization.

Most of the bore-holes, however, just penetrate into the Lower Anhydrite beneath the salt. The question of the thickness of the Limestone will be discussed when treating of the exploratory bore-hole at Seaton Carew. Over a great part of the country it overlies the coal measures, and, as will be seen by the geological map, passes beneath the red sandstone on a line about S.W. from West Hartlepool to the Tees.

Your attention should now be directed to the geological sections laid down on the diagram, and coloured according to the preceding classification of strata. Section 1 extends from the Warren Cement Works, Hartlepool, to Ormesby, on the south of Middlesbro', in a direction N. 5° E., S. 5° W. Its length is nine miles 280 feet. It is laid down twice, first on the horizontal scale of six inches per mile and vertical scale of one inch per 100 feet, and secondly, on the same scale (horizontal and vertical alike) of six inches per mile, which thus shows the actual proportions. Section No. 2 is three miles 2,805 feet in length, running N. 84° W.—S. 84° E., almost at right angles to No. 1. Section No. 3 runs from Seaton Carew bore-hole to the Tees, in a line N. 26½° E.—S. 26½° W. These last two sections are laid down on the dual scale only. The positions of the bore-holes are indicated by the same letters as show their position on the ordnance map. When the perpendiculars of the bore-holes are dotted the section lines do not pass exactly through them, but may be some distance on one side; but when the perpendiculars are fully marked, then the bore-holes are exactly on the section lines.

It will be observed that there is a general dip of the strata to the south and east.

The recent borings on the northern side of the salt field have thrown a great deal of light on the geological succession of the strata. Your attention would be more parti-

cularly directed to the five bore-holes A, B, C, D, and E, and the detailed boring sections are here given.

As all these borings were made by the Diamond Drill, and solid cores were obtained, their indications may be absolutely relied on.

(A.)

BORING AT WARREN CEMENT WORKS, HARTLEPOOL, 1888.

Strata.	Ft.	In.		Ft.	In.
Sand	22	0	....	22	0
Soft mud and peat	8	0	....	30	0
Red clay	18	0	..	48	0
Red pinnel with small cobbles	6	0	....	54	0
Dark pinnel and cobbles	18	0	....	72	0
Pinnel and cobbles	2	0	....	74	0
Dark pinnel and cobbles	19	0	....	93	0
Red clay	2	0	....	95	0
Soft limestone	1	0	....	96	0
Red clay	1	0	....	97	0
Hard rock	1	5	....	98	5
Anhydrite	265	7	....	364	0
Dark grey limestone	38	0	....	402	0

(B.)

BORING AT CELLULOSE WORKS, WEST HARTLEPOOL. 1888.

Strata.	Ft.	In.		Ft.	In.
Old well	37	0	....	37	0
Brown pinnel	13	0	....	50	0
Yellow clay	3	0	....	53	0
Yellowish white limestone (soft and porous)	135	0	....	188	0
Brown limestone	4	0	....	192	0
Dark shaley limestone, large-grained	33	0	....	225	0
Yellowish white porous limestone	12	0	....	237	0

Strata.	Ft.	In.		Ft.	In.
Anhydrite, with beds of dark blue shale and gypsum	35	0	....	641	0
Light grey limestone and gypsum	7	0	....	648	0
Blue shale	2	0	....	650	0
Light grey limestone	11	0	....	661	0
White limestone	90	0	....	751	0
Hard white limestone and gypsum	12	0	....	763	0
Dark grey limestone and anhydrite	20	0	....	783	0
Light grey limestone and gypsum	18	0	....	801	0
Light grey limestone	29	0	....	830	0
Limestone and gypsum mixed	31	0	....	861	0
Grey limestone and gypsum	11	0	....	872	0
Light grey limestone and gypsum	33	0	....	905	0
Light grey limestone	50	0	....	955	0
Light grey limestone, with spots of gypsum.	45	0	....	1000	0
White limestone	107	0	....	1107	0
Light grey limestone	23	0	....	1130	0
Broken light grey limestone (brine feeder)	23	0	....	1153	0
Light grey limestone	9	0	....	1162	0
Light grey limestone, with spar cavities	9	0	....	1171	0
Light grey limestone	7	0	....	1178	0
White limestone	82	0	....	1260	0
Light grey limestone, with a little gypsum	23	0	....	1283	0
Dark grey limestone, with gypsum	17	6	....	1300	6

(Proceeding.)

CONTINUATION OF SEATON CAREW BORING UP TO JULY 16TH, 1888.

(Received since the reading of the Paper.)

Strata.	Ft.	In.		Ft.	In.
Brought forward	..	..	....	1300	6
Magnesian Limestone.					
Dark Limestone, with spots of gypsum	59	6	....	1360	0
Dark Grey Limestone	40	0	....	1400	0
Lower New Red Sandstone.					
Dark Grey Shaley Sandstone	10	0	....	1410	0
Red and Grey Shaley Sandstone	17	6	....	1427	6

(C.)

BORING AT CEMENT WORKS, WEST HARTLEPOOL,

(Casebourne & Co.), 1887.

Strata.	Ft.	In.		Ft.	In.
Well previously sunk	30	0	....	30	0
Red sandstone	9	0	....	39	0
Red sandy marl	10	0	....	49	0
Red sandstone, with beds of red marl	31	0	....	80	0
Red sandstone and marl mixed	57	0	....	137	0
Red marl, with beds of red sandstone	27	0	....	164	0
Red and grey sandstone, with beds of red marl	26	0	....	190	0
Red sandstone	25	0	....	215	0
Red marl	35	0	....	250	0
Red marl, with beds of sandstone	20	0	....	270	0
Red marl	38	0	....	308	0
Red marl, with thin beds of red sandstone	32	0	....	340	0
Red marl	45	0	....	385	0
Red marl, with veins of gypsum	95	0	....	480	0
Red marl, with veins of gypsum and blue joints	55	0	....	535	0
Red marl, with blue joints	4	2	....	539	2
Red marl, with veins of gypsum and blue spots	4	6	....	543	8
Do. do. with blue joints	24	10	....	568	6
Do. do. with red sandstone	10	0	....	578	6
Strong marl, with thick veins of gypsum	21	6	....	600	0
Red marl, with veins of gypsum and blue joints	5	6	....	605	6
Anhydrite	4	0	....	609	6
Anhydrite, with veins of gypsum	12	0	....	621	6
Anhydrite	2	6	....	624	0
Blue marl	0	8	....	624	8
Red marl, with blue joints and veins of gypsum	27	10	....	652	6
Anhydrite	7	0	....	659	6
Anhydrite with black joints and veins of gypsum	11	0	....	670	6
Anhydrite, with black joints	16	0	....	686	6
Anhydrite, with spots of gypsum	18	6	....	705	0
Anhydrite, with gypsum	9	4	....	714	4
Anhydrite, mixed with limestone	15	8	....	730	0
Limestone, with gypsum	40	0	....	770	0

(D.)

BORING AT SEATON CAREW, 1887-1888.

Strata.	Ft.	In.		Ft.	In.
Brown clay	6	0	....	6	0
Red clay	6	0	....	12	0
Red pinnel and cobbles	9	0	....	18	0
Soft red sandy marl	12	0	....	30	0
Red sandy marl	3	0	....	33	0
Red and grey sandstone	7	0	....	40	0
Red marl	2	0	....	42	0
Grey sandstone	5	0	....	47	0
Red marl, with beds of sandstone	10	0	....	57	0
Red sandstone	20	0	....	77	0
Grey sandstone	2	0	....	79	0
Red sandstone	13	0	....	92	0
Grey sandstone	1	0	....	93	0
Red sandy marl	47	0	....	140	0
Red and grey sandstone	10	0	....	150	0
Red marl	15	0	....	165	0
Red marl, with beds of grey and red sandstone	8	0	....	173	0
Red marl, with blue joints	35	0	....	208	0
Red marl, with beds of grey sandstone	24	0	....	232	0
Red marl, with beds of grey marl	33	0	....	265	0
Red marl, with blue joints	24	0	....	289	0
Red marl, with blue joints and veins of gypsum	171	0	....	460	0
Red marl and veins of gypsum	7	5	....	467	5
Anhydrite	13	0	....	480	5
Blue marl and veins of gypsum	3	0	....	483	5
Anhydrite	1	0	....	484	5
Red marl and veins of gypsum	10	0	....	494	5
Dark marl and gypsum mixed	2	7	....	497	0
Anhydrite, with black joints	25	0	....	522	0
Magnesian limestone, with spots of gypsum.	27	0	....	549	0
Light grey magnesian limestone, with spots and veins of gypsum	38	0	....	587	0
Dark grey limestone, with spots and veins of gypsum	16	0	....	603	0
Dark blue shale (slight feeder of rock oil)	3	0	....	606	0

Strata.	Ft.	In.		Ft.	In.
Anhydrite, with beds of dark blue shale and gypsum	35	0	....	641	0
Light grey limestone and gypsum	7	0	....	648	0
Blue shale	2	0	....	650	0
Light grey limestone	11	0	....	661	0
White limestone	90	0	....	751	0
Hard white limestone and gypsum	12	0	....	763	0
Dark grey limestone and anhydrite	20	0	....	783	0
Light grey limestone and gypsum	18	0	....	801	0
Light grey limestone	29	0	....	830	0
Limestone and gypsum mixed	31	0	....	861	0
Grey limestone and gypsum	11	0	....	872	0
Light grey limestone and gypsum	33	0	....	905	0
Light grey limestone	50	0	....	955	0
Light grey limestone, with spots of gypsum.	45	0	....	1000	0
White limestone	107	0	....	1107	0
Light grey limestone	23	0	....	1130	0
Broken light grey limestone (brine feeder)	23	0	....	1153	0
Light grey limestone	9	0	....	1162	0
Light grey limestone, with spar cavities	9	0	....	1171	0
Light grey limestone	7	0	....	1178	0
White limestone	82	0	....	1260	0
Light grey limestone, with a little gypsum	23	0	....	1283	0
Dark grey limestone, with gypsum	17	6	....	1300	6

(Proceeding.)

CONTINUATION OF SEATON CAREW BORING UP TO JULY 16TH, 1888.

(Received since the reading of the Paper.)

Strata.	Ft.	In.		Ft.	In.
Brought forward	..	..	....	1300	6
Magnesian Limestone.					
Dark Limestone, with spots of gypsum	59	6	....	1360	0
Dark Grey Limestone	40	0	....	1400	0
Lower New Red Sandstone.					
Dark Grey Shaley Sandstone	10	0	....	1410	0
Red and Grey Shaley Sandstone	17	6	....	1427	6

COAL MEASURES.

STRATA.	Ft.	In.		Ft.	In.
Black Shale	**0**	**6**	**....**	**1428**	**0**
Dark Grey Shale	**1**	**0**	**....**	**1429**	**0**
Dark Grey Sandstone	**1**	**0**	**....**	**1430**	**0**
Grey Sandstone, with black joints	**40**	**0**	**....**	**1470**	**0**
Very Coarse Grey Sandstone	**15**	**0**	**....**	**1485**	**0**
Dark Grey Sandstone	**0**	**6**	**....**	**1485**	**6**
Black Shale	**0**	**6**	**....**	**1486**	**0**
Red and Grey Sandstone	**1**	**7**	**....**	**1487**	**7**
Black Shale	**12**	**4**	**....**	**1499**	**11**
Shaley Sandstone	**2**	**6**	**....**	**1502**	**5**
Black Shale	**10**	**0**	**....**	**1512**	**5**
Grey Sandstone	**4**	**0**	**....**	**1516**	**5**
Dark Grey Sandy Shale	**0**	**7**	**....**	**1517**	**0**
Coal	**0**	**10**	**....**	**1517**	**10**
Dark Brown Fireclay	**1**	**2**	**....**	**1519**	**0**
Black Sandy Shale	**2**	**8**	**....**	**1521**	**8**
Dark Grey Sandy Shale	1	8	....	1523	4
White Sandstone	26	8	....	1550	0
Dark Grey Sandstone	5	0	....	1555	0
Light Grey Sandstone	12	8	....	1567	8
Dark Shaley Sandstone, with coal joints	1	4	....	1569	0
Black Shale	9	6	....	1578	6
Coal	1	2	....	1579	8
Dark Black Shale and Fireclay	0	4	....	1580	0
White and Grey Sandstone	6	0	....	1586	0
Black Shale	8	0	....	1594	0
Fine Grey Sandstone	6	0	....	1600	0

(E.)

BORING AT MARSH HOUSE, GREATHAM.

(Greatham Salt Boring Co., Limited.)

STRATA.	Ft.	In.		Ft.	In.
Soil	1	0	....	1	0
Red and blue clay	3	0	....	4	0
Tough red clay	26	0	....	30	0
Red sand	4	0	....	34	0
Red sand and clay	15	0	....	49	0
Fine gravel	1	0	....	50	0
Brown sandy pinnel	1	0	....	51	0
Brown pinnel and cobbles	14	0	....	65	0

Strata.	Ft.	In.		Ft.	In.
Red sand	2	6	....	67	6
Hard round gravel	4	5	....	71	11
Red sandstone	300	7	....	372	0
Red sandstone with beds of marl	77	6	....	449	6
Red sandstone	15	2	....	464	8
Red sandstone with beds of marl	114	7	....	579	3
Red sandy marl	8	6	....	587	9
Red marl with blue joints	8	6	....	596	3
Red sandy marl	21	3	....	617	6
Red marl	20	3	....	637	9
Red marl with blue joints	21	8	....	659	5
Red marl with veins of gypsum	18	8	....	678	1
Red marl with veins of gypsum and blue joints	106	11	....	785	0
Red marl with veins of gypsum and blue spots	68	2	....	853	2
Red marl with veins of gypsum	9	10	....	863	0
Anhydrite	11	0	....	874	0
Red marl (rotten)	15	0	....	889	0
Rock salt	57	2	....	946	2
Salt and anhydrite mixed	14	3	....	960	5
Rock salt	11	4	....	971	9
Anhydrite	1	0	....	972	9

The borehole at Greatham is at present the most northern one which has proved the salt bed, and it is now ascertained that the salt bed disappears between Greatham and Seaton Carew.

The Seaton Carew boring was projected by the late Mr. G. T. Pearson, of West Hartlepool, and carried out by his executor in conjunction with the writer. It was soon found that the salt bed did not exist here, and the magnesian limestone was reached at 522 feet. It was, however, determined to continue the boring, with the idea of penetrating the magnesian limestone, and to ascertain whether the coal measures were beneath it. At 606 feet a bed of dark shale was pierced which gave off a small feeder of coarse black oil. At 1,150 feet a bed of brecciated limestone was pierced and found to contain a strong feeder of saturated brine.

The supposition is that this brine is draining from the salt bed on the south, the brecciated limestone having numerous cavities. The boring reached a depth of 1,300 feet, having thus passed through 780 feet of magnesian limestone, which is the thickest section of these strata yet recorded.* In the northern part of the county, where the magnesian limestone overlies the coal measures, its thickness does not exceed 500 feet. The coal measures crop out beneath the magnesian limestone near South Wingate, but it is possible that they may be brought in again to the south of Hartlepool. With a view to test this it has been determined to continue this boring to 1,600 feet, and this is now being carried out.

The upper beds in the limestone here are very pure, and it is contemplated to sink a shaft about 600 feet deep to work the stone for the use of local blast-furnaces.

A spring of strongly sulphurous spa-water has recently appeared in this borehole, and appears to come from the same bed of shale which gives off the rock oil. It is intended to analyse this water to determine its medicinal qualities.

The brine spring at 1,150 feet deep, if permanent and of sufficient volume, is very valuable commercially, as there is a strong cover of limestone above instead of the fragile "rotten marl" of the salt-bed.† There would thus be no fear of the collapse of the borehole, and the chance of surface subsidence would be very much diminished. Brine pumps will be put in as soon as the boring is finished.

About half-a-mile N.W. of the Seaton Carew borehole, Messrs. Casebourne & Co., Limited, put down a borehole in their cement works for water. It will be remarked that the limestone is not reached here till 200 feet deeper than it is found at Seaton Carew. An exposure of the red sandstone at the seaside shows this dip north very well.

* Total thickness of Magnesian Limestone since proved to be 878 feet.—W. J. B.

† Brine appears permanent since date of Paper.—W. J. B., July 13th.

A little further north, at the West Hartlepool Cellulose works, the red sandstones and marls have all disappeared, and the limestone is reached immediately beneath the boulder clay. An extensive fault must exist on the south of this boring.

The most northerly boring on the map at the Warren Cement Works, Hartlepool, shows an abnormal thickness of Anhydrite. This may probably be the Lower Anhydrite of the saliferous beds, although the one foot of limestone above it is rather against the theory.

In a paper by Mr. De Rance, in Vol. XV. of your Transactions, a section is given of a boring at Oughton, one mile west of Seaton Carew. This was bored in 1827 by the old-fashioned plant. It is to be feared that the section is very unreliable. The 4in. seam of coal is certainly apocryphal, occurring, as it would, in the midst of the red sandstones and marls. Attention was drawn to this boring at the discussion on Sir Lowthian Bell's paper before the Institute of Civil Engineers, and Mr. A. C. G. Cameron suggested that this boring should be continued to 900 feet. To give any reliable indications there would have to be a new borehole altogether at this spot.

By far the greatest number of these borings have been executed by the Diamond Boring process, by Mr. J. Vivian, of Whitehaven. This is the only satisfactory method to secure good sections. Boring can be carried out very expeditiously by this means, especially in the red sandstones and marls. In the case of the Greatham boring no less than 112 feet were bored in one 24 hours.

The bore-holes are generally six to eight inches in diameter, and are fitted up with pumps for raising the brine. It was originally considered necessary to run fresh water down from the surface, but this is now dispensed with, as the strata above the salt bed afford a sufficient supply of water.

No attempt has yet been made to mine the rock salt, and under the present condition of trade the economical disadvantage of rock salt mining as compared with brine pumping precludes this method of working. As yet there has been no trouble with surface subsidence, although several of the bore-holes have been destroyed by the collapse of the rotten marl above the salt bed. The following is an analysis of the rock salt from one of Messrs. Bell Bros'. bore-holes :—

	Per cent.
Chloride of sodium	98·42
Sulphate of lime..	·21
Chloride of magnesia..	·12
Water	·10
Red clay	1·5
	100·0

Up to the present South Durham has not contributed largely to the production of salt in the United Kingdom, but now the output is increasing rapidly, and in a few years time will bulk largely in the total production. Table II. shows the annual production of salt in the United Kingdom during the last three years.

TABLE II.

ANNUAL PRODUCTION OF SALT.

District.		1885.	1886.	1887.
		Tons.	Tons.	Tons.
Cheshire	Rock Salt ..	167,269	152,439	150,267
Cheshire	Brine Salt ..	1,687,456	1,604,400	1,619,452
	Total ..	1,854,725	1,756,839	1,769,719
Durham	Brine Salt ..	53,937	98,562	136,267
Staffordshire ..	Brine Salt ..	5,810	5,810	5,810
Worcestershire	Brine Salt ..	270,000	260,000	252,000
Ireland	Rock Salt ..	23,211	21,009	30,155
Total Production		2,207,683	2,142,220	2,193,953

The production for the whole country thus is almost stationary, whilst in South Durham it is increasing about 40 per cent. per annum, and the output is expected to amount to 200,000 tons this present year. The excellent facilities for shipment are beginning to develop an export trade, but up till now the main consumption has been at the local chemical works.

In conclusion, it only remains for the writer to express his obligations to those gentlemen who have assisted him with information, which has been of use in the compilation of this paper, viz., Messrs. Dickinson and Bell, H.M. Mines Inspectors; Mr. C. T. Casebourne, C.E., of West Hartlepool; Mr. C. Trechmann, Hartlepool; and Mr. John Vivian, Whitehaven.

The PRESIDENT intimated that the subject was open for discussion, and invited Mr. Thomas Bell (H.M. Inspector of Mines for the Durham District), who was present, to address a few words to the meeting.

Mr. BELL said he did not think that he could add anything to what Mr. Bird had already said. He had gone very fully into the subject.

The PRESIDENT: You can tell us, Mr. Bell, about the 200 yards borehole where they failed to prove the salt.

Mr. BELL pointed out the position of the several boreholes on the map, and indicated that to which the President referred, made by the Newcastle Chemical Company. The bed of rock salt, he said, must turn, or stop abruptly, at that point, probably owing to the occurrence of a fault; because the salt again appeared further to the south. At Seaton Carew the boring went right down into the limestone, as described. He pointed out what appeared to be the northern boundary of the salt bed, and observed that southward it appeared to extend for a considerable distance. The

output of salt in that district at present was about 140,000 tons per annum. The consumption of salt for the manufacture of soda on the Tyne, as stated by Mr. Hugh Bell in his work, was about 200,000 tons a year; so that they were fast approaching the period when the local production would supply the whole of the Tyne works. He saw in that morning's papers that there had been about 16,000 tons of salt exported during the last seven months to places on the Continent. He hoped that, in a few years, they would have more holes put down, and that the salt field would be considerably extended.

The PRESIDENT: Referring to the Seaton Carew hole—What depth was that before they reached the magnesian limestone?

Mr. BIRD: 522 feet.

Mr. BELL: That hole is now 1,360 feet down. That deposit of magnesian limestone is the thickest we have met with anywhere on the north-east coast. It can be seen all the way along the coast from Hartlepool to Castle Eden, Ryhope, Seaham Harbour, and on to the Tyne, where it again disappears.

The PRESIDENT: At Seaton Carew you have got 522 feet above the magnesian limestone without salt?

Mr. BELL: Yes.

The PRESIDENT: What is the distance between the magnesian limestone and the salt in the other boreholes mentioned in that table?

Mr. BIRD: Take as an illustration the section at Greatham—that is the most northern hole in which salt has been found. The total thickness of the saliferous beds is 109 feet, above the magnesian limestone—that is the total thickness proved.

The PRESIDENT: And the thickness between the magnesian limestone and the salt?

Mr. BIRD: It has been pierced in three or four places—about 40 feet, I think.

The PRESIDENT: Then at Seaton Carew you have 522 feet of marls and red sandstones, and no salt in it?

Mr. BIRD: Salt is invariably found between the two anhydrites, the upper and the lower, without any exception whatever.

The PRESIDENT: And none of the salt is below the magnesian limestone?

Mr. BIRD: Oh, yes.

The PRESIDENT: Are you quite sure of that? I see Sir Lowthian Bell, in his paper read before the Association of Civil Engineers, said that some magnesian limestone was found overlying the salt. Is that clearly settled?

Mr. BELL: I think it is not the case. I asked Mr. Hugh Bell if he would let his chemist test that, and he told me afterwards that it was not magnesian limestone. I was very particular about that. The chemist (Mr. Thomson) made his analysis after the book was printed.

The PRESIDENT: I thought the statement of Sir Lowthian Bell was doubtful on that point, and that he had got into error with regard to some of the magnesian limestone being above the salt. The whole interest of this paper consists in these minute divisions; it raises the question as to whether these salt beds, as situated, are in the Permian or above.

Mr. BIRD: Yes.

The PRESIDENT: It is on one of the minute divisions of this kind that the whole issue hangs.

Mr. BELL: The magnesian limestone has never been mentioned as overlying the salt except in the trial hole of Bell Bros. That is the only section where we have it mentioned.

diminished, but only diminished to the extent of the thickness of the salt bed. Down to 522 feet, the beginning of the magnesian limestone, the succession of the strata at Seaton Carew is exactly the same as elsewhere.

Mr. BELL: There seems to be a general thinning out of the strata towards the north. The red is thinned out to about 500 feet at Seaton Carew, and I was told that in digging the foundations of a church at West Hartlepool they began in the red and finished in the magnesian limestone.

The PRESIDENT: Amongst all the borings you have got is there any one which proves that the salt bed has been found extending under the lias?

Mr. BIRD: None, whatever; as you see from the geological map.

The PRESIDENT: Yes; but you are giving us now explorations made quite independently of the geological map, and which may correct the geological map.

Mr. BIRD: Yes; but none if the explorations pass through the liassic beds. Those beds would have fossiliferous indications.

The PRESIDENT: Your borings, as far as they go, do not solve the question I put in the address from which I quoted.

Mr. BELL: I am afraid not. There is no evidence of rock salt being found underneath the lias, as far as I am aware.

In reply to a further question by the President,

Mr. BIRD said: We certainly have proved the salt beds existing under the upper gypseous marls at Eston; but there is no allegation that those marls are at all liassic.

The PRESIDENT: Speaking from memory, there is some

60 yards with gypsum at Middlesborough, where Messrs. Bolckow and Vaughan put down their first bore-hole. Then there is 300 yards of red sandstone, without pebbles; and then they reach the saliferous marls.

Mr. BIRD quoted the exact figures relating to the borehole referred to, and, in reply to the President, said he accounted for the salt not being present at Seaton Carew from its having thinned out. That thinning out, he added, was undoubtedly gradual. There was proof of that in the case of other boreholes which had not proved salt at all.

The PRESIDENT: I was in hopes that the problem would have been solved by these borings in the North of England. Some of you, who know the Cheshire salt field, will know that the salt lies on different formations. It is lying, if you go to the south-east, near Congleton, on the mountain limestone; then coming north, to Alderley, it rests upon the new red sandstone; and then it takes a sweep over various formations around, and in the extreme south, adjoining Shrewsbury, there is the lias, and the geological maps and sections show you that that lias is overlying the salt. But has it ever been proved that it overlies the salt? There have been boreholes put down showing nearly 100 feet in thickness of sand, but for anything that has actually been demonstrated, the salt marls may lie round about that lias, with the lias intruded up between. I think it is a question that should receive more consideration than has been given to it. Just after that address of mine was delivered here I had a long talk with one of the London geologists on the subject, and he said the same idea had occurred to him, and he would like to know if anybody had proved salt lying underneath the lias.

Mr. BIRD, in replying upon the discussion, said: I have nothing to say by way of reply beyond this, that we have not yet achieved the desideratum of proving the existence

of the salt bed beneath the lias, and considering that the liassic rocks only come in a good way beyond the present known limit of the salt bed, it will be a considerable time before there is any attempt to prove it. Sufficient salt can be raised from the area of salt field already proved, to supply local trade requirements, there is, therefore, no financial motive to induce speculators to operate very far to the south-east of the present area. They would have to go very considerably to the south-east to have a chance of passing through the liassic strata.

DISTRIBUTION OF ERRATICS AND BOULDER CLAY ON THE LOWER PORTIONS OF THE DRAINAGE AREAS OF THE OLDHAM CORPORATION WATER-WORKS.

By Mr. William Watts, F.G.S.

DRAINAGE AREAS.

The drainage areas of the Oldham Corporation Water-works is 5,680 statute acres, and consists of the upper limits of four valleys in the south-westerly slopes of the Pennine Chain, two of which are in the south-west corner of Yorkshire, one in Lancashire, and one partly in Lancashire and partly in Yorkshire.

The separate areas are as follow, viz.:—

	Acres.
Strinesdale and Brushes Clough	1,360
Piethorn	1,920
Denshaw	1,450
Castleshaw	950
Total	5,680

The highest portion of this drainage rises 1,600 feet above the ordnance datum, and is mainly composed of moorland scenery of the wildest kind.

The slopes have been rounded off by the ordinary process of denudation, with the exception of a narrow strip of serried rocks of the Kinder Scout Grit on Millstone Edge, Saddleworth.

The greater part of the drainage lies on the outcropping measures of the lower coal beds between that known as the Mountain Mine on the one hand, and the Yoredale shales on the other.

The top water level of the highest reservoir is 1,268 feet above the sea, and the lowest is 680 feet.

The water from the Strinesdale area falls into the Medlock, Piethorn into the Roach, Denshaw and Castleshaw into the Tame.

For brevity and convenience I purpose to refer to each of the valleys or drainage areas above named separately, and then to give a list of the boulders found which have been kindly named, through the kindness of Dr. Crosskey, by Prof. Lapworth, of the Mason College, Birmingham.

I am deeply grateful to those gentlemen for their ready and willing help in naming the specimens, as well as to our Hon. Secretary, Mr. Stirrup, for referring me to Dr. Crosskey when the subject of a wider search for erratic boulders by the members of the Manchester Geological Society was brought forward in connection with the meeting of the British Association last year at Manchester.

The erratics, to which I shall presently refer, have all been gathered between the 630 and 950 feet ordnance datum, with the exception of specimen No. 4, which was chipped from a perched block about 4ft. by 3ft. by 2ft. 6in. on Nicholas Pike, 1,050ft. above the sea, and which overlooks the beautful vale of the Roach, about four miles north-east of Rochdale.

STRINESDALE VALLEY.

Strinesdale Valley is situated about two miles from the Town Hall, Oldham.

The valley is carved in the Lower Coal Measure Shales, and some of the coal seams which exist not very deep beneath the surface of the ground have been worked by neighbouring collieries, but which have ceased working within recent years.

The boulder clay which nestles in the lower portion of the valley is consequently dark coloured, and contains a good number of local grits derived from the gannister beds, intermingled with erratic blocks and foreign pebbles, which may have been washed into the clay, which is coarse and of an impure quality in the area which I have more particularly examined between the 740 and 830 feet Ordnance datum.

The erratics are not large, but they are numerous and well rounded, and appear to have been tossed about by the action of water, which I infer from the fine scratchings found on the smooth surface of the lesser boulders.

Intermixed with the clay, wet veins of coarse sand occur, also pocket holes of loam, which will not bear trampling on by the workmen engaged in excavating it.

When the larger stones are picked out, this clay makes an excellent puddle for waterworks purposes; the grit and small pebbles which it contains help it to set and resist the action of water better than a richer clay.

Doubtless, the water which has flowed down the valley since the last glacial period has done much to reassort the material above the level of the brook, but before it reached its present level.

The water, however, has not bared the basement strata of the valley except in a few places, but it has moved from

side to side, and left behind coarse and fine *debris* to bear testimony of the power of floods in past time.

In most upland valleys—owing to their narrowness—the boulder clay is coarser than the contemporary clays found on the plains, in consequence of local grits dropping into it whilst deposition is going on.

Although isolated boulders are found at a height exceeding 850 feet above the sea I have not seen the typical drift clay above that height in this valley, but my observations have been limited to the undisturbed ground, and not to actual excavations, which are so essential to the investigation of geological strata.

Many of the boulders are scratched and striated, and show signs of much attrition.

By far the greater number belongs to the Silurian or Metamorphic rocks. Recently I found a fragment of *Syringopora reticulata*, which I exhibit.

PIETHORN VALLEY.

One of the most interesting drift deposits which I have seen on the slopes of the Pennine chain lies in the lower part of Piethorn Valley, where the Ogden embankment is placed.

The clay, in addition to the gravel above it, is 35 feet in depth, and doubtless was formed in deep water by melting and floating ice.

Three hundred yards below the site of the embankment the valley is not more than 100 yards wide at the bottom, and cut mainly in the Elpit Edge rock. Through this gorge the water from 2,000 acres has flowed since the district assumed its present configuration, and through which also the land ice would have to squeeze itself,

assuming the hills above had discharged frozen snow during the last glacial period.

Immediately below the narrow part of the valley here alluded to there is a deposit of drift of about two acres in extent, and 20 to 25 feet above the brook course level. This deposit lies in such a manner that leads me to infer that it was left by drifted ice not able to pass through the gorge when the Pennine hills were slowly uprising, and is of later date than the drift in the higher part of the valley.

Knowing the physical features of the district so well, this seems to me a reasonable hypothesis.

I would further add, that the bottom of the 35 feet of boulder clay, under the seat of the embankment, is about level with the deepest part of the gorge at Wood Mill, where the clay is absent and the shales appear, which immediately overlie the Mountain Mine coal.

Icebergs driven into this corner would be subject to packing by the waves of a glacial sea moving from the south in a north-easterly direction.

Prior to the commencement of the waterworks the water flowing from the 2,000 acres of drainage had formed a channel in the boulder clay but had not cut through it, and whether it had flowed at a lower level in pre-glacial time is conjectural; but the fact remains that the clay fills the valley, which at one time was 12 yards deeper and somewhat narrower. The clay is twisted and crumpled, and changeable in colour, which character must have been acquired after deposition and partial consolidation.

The pressure of ice or local landslips would account for the phenomenon, but as there are no local indications of land having moved since glacial time, ice alone must have been the mixing and disturbing agent, both to crumple and peroxidise it in irregular patches.

Underneath that clay a black, silty deposit, charged with

local grits, exists, which has the appearance of an ancient lake bottom, which is very interesting.

The physical features of the lower end of the valley favour the idea of a lake, if we regard the narrow part at Ogden Mill as the place where the outlet or overflow existed at the time.

The larger erratics found in the clay appear to have been dropped *in sitû* whilst it was in the condition of mud. Several erratics upwards of two tons in weight have been found, and a hornblendic boulder 4ft. 6in. by 3ft. 0in. by 2ft. 6in. may still be seen on the north-westerly side of the valley lower down than Kitcliffe Mill. The angles of this erratic are worn off, but it does not appear to have suffered very greatly during its passage, as I could not trace any glacial markings on its surface.

Smaller boulders are numerous, and specimens similar to those on the table may be found spread over the lower part of the valley from the 630 to the 950 feet ordnance datum.

I give at the end of this communication a list of the erratics, therefore I will not trouble you by enumerating them here. I must, however, call your attention to three specimens which deserve more than a bare mention, viz., specimens Nos. 1, 2, and 3.

No. 1 is Criffel granite from the south of Scotland. It is sparingly represented in the trail of the Lake boulders, and does not reach more than one per cent. of the whole; but it is a welcome boulder to every geologist who has searched the drift on the Pennine Chain in the neighbourhood of Manchester.

No. 2 is Eskdale granite from Cumberland, and represents at least five per cent. of the whole. These boulders are always rounded but sparingly striated.

No. 3. *Gryphœa incurva* I found in the clay at Ogden, and had I not discovered the specimen myself I certainly

should have doubted its genuineness, as the fossil is rarely met with in the boulder clay of the district, and is in good preservation, which is remarkable, seeing that the drift has been so much tossed about.

Syringopora reticulata and *Syringopora geniculata* are represented in my table of "finds," and owing to the delicate structure of the former, it must have had a peaceful passage, as the pipes are very fragile, and easily destroyed. The specimen was much larger when I found it, but with handling and lending it has got less, and, except it be better cared for in the future, will shortly disappear.

Specimens of Old Red Sandstone occasionally turn up, some of which have the characteristic purple markings.

This rock, however, is not common, owing, doubtless, to its perishable character.

Flint nodules also turn up; but as this material was extensively used by primitive man for weapons and implements of domestic use, it may have been conveyed here by him and not by the agency of ice. At one time I had in my possession a nodule of flint fully eight inches long by about three inches in diameter, which I found in the drift at Ogden, but it disappeared from my cabinet some years ago, and has not found its way back. Pebbles of various kinds are numerous in the gravels, and are as pretty as they are numerous.

Some of the local grits are beautifully polished, especially those of gannister, which are fine grained; some also are polished in the form of ovate spheres, and make us wonder how the agency of water had shaped them so prettily.

Carboniferous Limestone is common in the drift of the district.

Permian nodules containing *Schizodus* occasionally turn up, one of which is on the table; also specimens of ironstone.

DENSHAW VALLEY.

This valley forms the south-west corner of Yorkshire. It is deep and tortuous, the hills rising to an altitude of about 1,600 feet on the moors above Readycon Dean.

There is no boulder clay in the valley above Denshaw—a small, old fashioned village two miles from Delph—but I have found several boulders, rounded and sub-angular, some of which are striated.

They vary in size, but mostly run about 12 to 24 inches in the three dimensions.

I have not succeeded in finding erratics higher up the valley than Dowry reservoir, 940 feet Ordnance datum. Several boulders are still exposed in the bed of the small brook course which receives the drainage from Broadhead, Noddle, and Ox Hey jointly, not more than 100 acres in area.

About 80 yards higher than where New Year's Bridge Mill stood, and where the above brooklets meet, I counted several erratics in the space of 30 square yards, all buried about 3 feet below the surface of the ground. I have preserved two of them—each weighing about 5cwts.—one a Syenitic quartz-felsite from the Lake district (No. 10), the other a coarse-grained Hornblendic Diorite (No. 8).

Whether the sea has been concerned in the dispersion of these boulders I will offer no opinion. Had floating ice, however, been the medium of conveyance it would seem that smaller boulders should have been found, but they have not to my knowledge.

I found a very nice pink-coloured quartz pebble, 3in. by 2½in. by 2in., at Readycon Dean, 1,200 feet above the sea, and several smaller pebbles—mostly quartz—lower down, which may have been washed into the valley *debris*.

The covering on the basement rocks is very slight, which leads me to the conclusion that they have been swept clean

after re-emergence either by ice or greater floods than prevail at present.

Where the harder rocks crop out at the surface they are much broken and dislocated, but expansion and contraction from heat, and to which must be added moisture, will account for the phenomenon; also a heavy weight, such as many hundred feet of ice slowly moving on them.

I have found no marine strata above the Junction, and I have no hopes of it being discovered above Denshaw Print Works, as the valley sides are tolerably steep and unfavourable to the retention—for lengthy periods—of soft material subject to attack from atmospheric agencies.

CASTLESHAW VALLEY.

The floor of this valley is on the Yoredale Shales, which commence at the ancient village of Delph, 650 feet above the level of the sea, and rise to an elevation of 1,200 feet at Millstone Edge. This valley, in my opinion, is one of the last formed in the Saddleworth district, but as I may make it the subject of a future communication to the Society, I will not say more on the subject of its age at present.

Several erratics have been found, but no boulder clay. With one exception all the boulders hitherto discovered are small and mainly syenitic. The largest, 800ft. above the sea, lies in a field near to a footpath leading from Waters Lane to Castleshaw.

The upper side only is exposed, and measures 4ft. 6in. by 2ft. 6in. It is a coarse-grained sub-angular block of Hornblendic character.

Further excavations may bring others to light, but I do not anticipate many will be found.

Boulder clay need not be looked for on the higher side of Delph in the direction of Castleshaw.

I believe, however, that it exists at New Tame leading to

the Heights Church, but I have not seen sufficient of it to pronounce it typical; it is blue, tenaceous, and stony.

Gannister blocks lie scattered in the alluvium in various places in the valley, and appear to have been subjected to much attrition by the action of water.

The blocks evidently belong to the Lower Coal Measure series, and probably have not travelled far from their present resting place.

Hundreds of massive Millstone Grit blocks lie scattered on the slopes of Millstone Edge, and many lie buried in the alluvium a few feet beneath the surface of the ground. Some of them have travelled more than half a mile from their parent bed at Millstone Edge, brought down by floods and other causes, and represent the weathering back of the serried rocks overlooking the beautiful valleys of the upper reaches of the Tame.

It is interesting to notice how these blocks get buried. The lower ones are barely covered, but as the summit of the hill is approached they lie deeper in the ground and become more numerous. I can understand the number increasing nearer the source whence they were derived, but I cannot satisfactorily account for the thin covering at the foot of the hill, except that the alluvium was deposited before the blocks of stone fell upon it, which seems very probable.

I have not been able to find a trace of marine deposit of the tertiary period intermixed with the strata, therefore, the locally scattered grits owe their position to local phenomena.

Some of them are several tons in weight, and weathered on the under-side as well as on the upper surfaces, showing that they have been exposed all round to atmospheric agencies in time gone by.

Most of the clay in the valley above the level under review is disintegrated from the shales and the laminæ of the latter, in some of the sections I have seen opened out

disappear in the former by the permeation of rainwater and changing temperatures.

If I could transport some of the sections to this room you would see how naturally the change ensues.

Seeing that the valleys in the Pennine range trend in various directions, some wide and some narrow, varying according to the nature of the material into which they are carved, it is difficult to understand what portion has been subjected to glacial action and what portion to the ordinary agencies now in operation.

If an ice-cap had moved over the district in past time, it must have filled the valleys to the level of the surrounding hills, which level would form the floor on which the ice would move, and thus the deeper and irregular valleys would be protected to a certain extent, and it seems to me that the main features are pre-glacial. This idea suggests the slow uprising of the hills since the last glacial period, as it is not probable that they would be buried under moving ice of great thickness at their present altitude, unless the centre from which the ice-sheet flowed was very much higher.

The study of glacial phenomena is very interesting, and always affords scope for difference of opinion among geologists, as there are so many standpoints from which the subject can be surveyed.

In this communication I have endeavoured to steer clear of the controversial issues of my subject, aiming the while at a modest statement of the facts and the physical features of the districts over which I have hurried this afternoon.

It now remains for me to show you the various specimens to which I have so frequently referred, and which I have been many years collecting.

Besides the specimens laid on the table, I have others unnamed, but of less value, which I have not brought with me.

The pebbles I have not enumerated, although they would, I am sure, form a very interesting collection.

I have avoided using the term "boulder" in reference to the local grits, regardless of its shape and character, believing that it should be applied in reference to the fire-formed and transported boulders only.

I purpose to hand over to the Oldham Museum my petrological specimens, and such duplicate specimens as I have remaining to the Manchester Geological Society for presentation to the Owens College Museum.

In the latter museum, under its present able Professor, I received my first practical lessons in geology, and as an old student in the old and new colleges would still bind the associations.

LIST OF ERRATIC BOULDERS FOUND ON THE DRAINAGE AREAS OF THE OLDHAM CORPORATION WATERWORKS.

No.	Species of Boulders.
1.	Micaceous granite—two micas. *Criffel, South of Scotland.* (?)
2.	Coarse grained granite. *Eskdale, Cumberland.* (?)
3.	Gryphœa incurva. Lias.
4.	Syenite.
5.	Quartz rock.
6.	Medium grained Syenite. Mica Syenite.
7.	Schist, filled with segregated quartz.
8.	Hornblendic rock. Diorite.
9.	Purple iron stained siliceous breccia. *Borrowdale.* (?)
10.	Syenitic quartz felsite. *Lake district.* (?)
11.	Porphyritic augite. Andesite. Dacite.
12.	Altered fine grained micaceous granite. Mica or hornblende altered.
13.	Fine grained granite. *Probably Lake.*
14.	Augitic basic igneous rock. Altered. *Borrowdale.* (?)
15.	Porphyritic andesite.
16.	Quartz felsite. *Lake district.* (?)
17.	Permian nodule, containing Schizodus shells.
18.	Fine grained Syenite. Buttermere. (?)

No.	Species of Boulders.
19.	Siliceous Rock. Ferruginous. *Borrowdale.* (?)
20.	Siliceous hornstone. Rhyolitic series. *Coniston.* (?)
21.	Fine grained Porphyritic andesite igneous rock. *Borrowdale.* (?)
22.	Fine grained greywaché.
23.	Altered. Carboniferous shale, ferruginous.
24.	Quartz felsite. Hornblendic.
25.	Crushed igneous rock. Serpentinous.
26.	Compact felstone, slightly porphyritic.
27.	Volcanic conglomerate.
28.	Syenite from *Ennerdale.* (?)
29.	Ennerdale granite, passing into greenstone.
30.	Upper Silurian Grit.
31.	Lower „ „
32.	Felstone.
33.	Passage rock between Syenite and Greenstone.
34.	Greenstone of the Lake district.
35.	Fine sedimentary Limestone.
36.	Porous Trap.
37.	Bunter Sandstone. Pebble Beds.
38.	Gannister nodule. Polished.
39.	Iron ore.
40.	Black Chert.

NOTE.—With the exception of 3, 5, and 17, the first 25 specimens are those named by Prof. Lapworth. The others have been named by D. Mackintosh, F.G.S., of Birkenhead; Wm. Shone, F.G.S., of Chester; and myself.

Mr. RADCLIFFE said that boulders of the kind exhibited by Mr. Watts were to be found over a widely extended area. They occurred on the moors above Saddleworth, Mossley, Stalybridge, and also at Ashton and Dukinfield. Similar examples to those on the table had been picked up at a height of from 500 feet to 900 feet above the sea in many places; and there was no doubt that the agency which had carried those exhibited by Mr. Watts had distributed them all over the district. They evidently came from the same source.

Mr. WATTS, in replying to a question by the President, said he had never been able to find the boulder clay at a

higher level than 850 feet ordnance datum; and the highest boulder he had found was at 1,050 feet, on the hill overlooking Hollingworth Lake. With reference to the remarks of Mr. Radcliffe he said he had purposely confined himself to the Oldham drainage area. He had charge of the Ashton and Stalybridge Water Works at Swineshaw, three miles from Stalybridge, and could bear out Mr. Radcliffe's statement, that such boulders as those he had described were to be found in that and other drainage areas. He had found them himself.

The PRESIDENT: A point of interest in a paper of this sort is to ascertain from what direction these stones have come, and I think Mr. Watts was somewhat indefinite when he said that one of these pieces of granite had come from the south of Scotland. What part of the south of Scotland was meant, and would it be in the general lie of the direction from which the drift has come?

Mr. WATTS said the locality mentioned was Criffel, in Kirkcudbrightshire. There was no doubt now that the bulk of the boulders had come from the lake district of Cumberland.

The PRESIDENT: According to your list they are chiefly granite, syenite, and rocks of that character. May I ask where that fine fossil shell has come from?

Mr. WATTS: I cannot tell you. It is liassic, but from what direction it has travelled into this district it is impossible to say. It is very interesting, and I agree with the President that if it could be ascertained in what directions these things have travelled, one interesting problem in geological science would be solved.

The HON. SECRETARY (Mr. Stirrup) said: This is the first of a series of papers which I hope we shall have presented to us on the distribution of erratic blocks around Manchester. As you are aware, we have, in recent years,

become one of the Corresponding Societies connected with the British Association, and in that capacity it is thought that some of our members could render valuable assistance to the Erratic Blocks Committee formed by that Association, which has been assiduously collecting materials for the last 15 or 16 years, as to the mode of occurrence and distribution of erratic blocks; it is, therefore, desirable that those investigations should be extended over all parts of the country as far as it can be done. I appealed to Mr. Watts, knowing that he lived in one of those moorland districts in the neighbourhood of Manchester, and, as Manager of the Oldham Waterworks, was well placed for undertaking observations of this kind; and he has very kindly undertaken them, and we have had an example to-day of what he is able to do for us. The results of his investigations will be forwarded to the Boulder Committee of the British Association, in connection with which Dr. Crosskey is plotting these different finds of stones on a large map with a view to ascertain the direction of the flow, and the district from which the boulders have probably been brought. Some of them can with great probability be assigned to their place of origin. Many of the granites are so common over the whole district that we find them in every brickfield around Manchester, and they extend northwards towards the district from whence they came. With regard to the lias fossil, *Gryphæa incurva*, it is an interesting question from whence that came. It has been said that the hard chalk and flints of Antrim have been found in some of our Lancashire deposits. There is a lias deposit also in County Antrim, which may be traced at intervals along the coast at the base of the chalky escarpment from Larne to the Giant's Causeway, in which these fossils occur in great abundance. It is quite possible that that may have been its place of origin.

AN ACCOUNT OF SMALL FLINT IMPLEMENTS FOUND BENEATH PEAT ON SEVERAL ELEVATED POINTS OF THE PENNINE CHAIN, LYING BETWEEN HUDDERSFIELD AND OLDHAM.

By Messrs. Robert Law, F.G.S., and James Horsfall.

In our paper read before the Yorkshire Geological and Polytechnic Society, published in Part I., Vol. VIII., of the proceedings of that Society in 1882, it was pointed out that a large number of flint implements had been discovered in no less than 34 different locations on that part of the Pennine Chain which lies within a radius of about 12 miles from Rochdale. Previous to that time, nearly all the flints had been found on ground laid bare by natural denuding agencies, or as at Bull Hill and one or two other places, where the peat had been removed for domestic purposes. Following up our investigations, we have been able to add a few localities to the list of places we had previously explored, and bring to light many more of these ancient flint tools and weapons, such as chips, flakes, cores, leaf-shaped and barbed arrow-heads, thumb-stones, and scrapers.

After carefully removing the peat in several places, and closely examining the bare ground, we have come to the conclusion that the true position in which flints are to be found is in the layer of grey sand and sandy loam occurring immediately beneath the peat.

This layer of grey sand and sandy loam in which these ancient relics are scattered has an average thickness of about

8 inches. It appears, in most instances, to have been formed by the decomposition "in situ" of a thin bed of sandstone. Large and small angular fragments of this rock are common throughout the sand.

Perhaps the most interesting flints found on these elevated moorlands are some very small and delicately-worked implements,* the largest not being more than an inch in length and a quarter of an inch in breadth, while the smallest does not exceed a quarter of an inch in its longest part.

Dr. John Evans, F.R.S., to whom a number of these small flints have been submitted, believes they may have been used as "carving tools," and that they are the smallest flint implements that have as yet been found in England.

Professor Dr. Ferdinand Römer, of Breslau, Silesia, Germany, has also expressed an opinion that similar flint tools have not to his knowledge been found on the continent of Europe before. These small flints vary much in size and shape, and, without following any true geometrical figures, they fall under three distinct types. 1st. Triangular, which is the most abundant type, and seems to have been formed by working unequally along the edge of a thin and narrow chip of flint, bringing one end down to a needle point, while the other end has a comparatively blunt termination. 2nd. Oval, a type produced by chipping equally along both edges, forming a sharp point at each end. 3rd. Tapering, a form which is the result of chipping a thin and very narrow piece of flint and gradually contracting it to a single sharp point.

The following table shews the localities where these small implements have been found, and the number obtained:—

* For illustrations of some of these, see the paper quoted above, York. Geol. Polyc. Socy., Vol. VIII., 1882, Plate III., Figs. 15, 16, 17.

Localities.	No. found.
Bull Hill, near Ramsbottom	1
Middle Hill, near Whitworth	2
Langfield Moor, near Todmorden	1
Wadsworth Moor, near Hebden Bridge	1
Dean Clough, Saddleworth	3
Hill to the south of Dean Clough (Saddleworth)	2
Cupwith Hill, near Marsden	9
Foot of Pule Hill, near Marsden	1
March Hill, near Marsden	60
Total	80

March Hill, where far the greater number of these small implements has been obtained, is an isolated and conical eminence overlooking the vale of Marsden. Its summit is about 1,400 feet above the level of the sea; towers considerably above the line of glacial detritus in the neighbourhood, so that fragments of flint and chert which it contains, "all foreign to the district," must have been deposited by man. During our search for flints we made several excavations on the hill, and the section exposed was as follows:—

1st. Peat from 10 to 16 inches thick.

2nd. Dark peaty-clay from 2 to 6 inches thick.

3rd. Dark grey sand 6 inches thick, containing angular pieces of sandstone, "local." Flints occurred at all levels in this layer.

4th. Red ochreous sand, about 12 inches thick, resting on Yoredale shale.

Not a particle of flint was found in either of the two uppermost layers, and their comparative abundance in the dark grey sand makes it extremely probable that they were there prior to the deposits of peat and peaty-clay. The number of small chippings, cores, flakes, and worked fragments—many of them broken—was so great as to lead to the

inference that flint implements were manufactured on the hill during pre-historic times, and this inference is strengthened by the finding of some unfinished small tools and corresponding parts of broken tools. The nearest chalk district to March Hill is about 60 miles away.

The PRESIDENT said the author did not seem to go into the question of whether or not these flints had been dropped by the primitive hunters, which was by some supposed to account for their occurrence.

Mr. WATTS said: I think I can testify to the faithfulness of the paper just read, and I may say that I have had some experience in the finding of these flint chippings, of which I could have brought many specimens. The section shown in the diagram exhibited is a typical one of March Hill. I have searched often for these chippings on March Hill, and other eminences, and as it is a very interesting —to a beginner even a fascinating—pursuit, I will explain briefly how it is done. First of all you have the peat, and underneath that the grey sand in which the flakes are found. The way to get them is this: You uncover a part of the surface of grey sand, and with a trowel turn it over. If the bed be a prolific one you will get a number in a very short time; but you may have to search days before finding such a bed. Last summer, in about an hour's time, I picked up about 31 different specimens of the types shown in the diagram,* and since then, in the neighbourhood of March Hill I have found a very pretty Neolithic hatchet which had been dropped by one of the

* Mr. Law, who was not present at the reading of his paper, writes, "it is doubtful if the 31 specimens of flints alluded to by Mr. Watts be implements at all. They are more likely to be chips or small flakes, as it seems incredible to me that such a number of implements could be found in one hour."

primitive men in a cleft of the rock where we are excavating for our works. March Hill is quite near to our Denshaw works; it is the highest point in the district, looking down into Marsden, and the Neolithic hatchet I found was on the Millstone Edge rocks. I regret I did not bring it with me to this meeting.

Mr. STIRRUP: Are there ever any arrow heads found with these rude flint flakes?

Mr. WATTS: Yes.

The PRESIDENT: Would you suppose that these flints were chipped or manufactured in the locality where they are found; or were they imported in the manufactured state? The making of gun flints at the present day is carried on in the chalk districts.

Mr. WATTS: I think the distribution of them is too wide for them to have been dropped indiscriminately, as the places where found afford evidence of their having been manufactured there. No doubt flint nodules, or flints in some shape, were imported into the district, and there manufactured into primitive weapons.

ON THE RECENTLY DISCLOSED SECTIONS OF THE SUPERFICIAL STRATA ALONG OXFORD STREET, MANCHESTER.

By Mr. THEODORE SINGTON.

During the construction of a sewer along Oxford Street, Manchester, from the River Medlock to the city boundary, at a depth of about 30 feet, details of the superficial deposits have been obtained which have enabled me to prepare the geological section illustrated on the plate. It extends from the river to High Street; the remaining portion will be illustrated in a future communication.

Commencing at the river, a thick bed of clay extends to a point intermediate between Boundary Street and Rosamond Street, where it abuts against the New Red Sandstone, a great mass of which rises abruptly across the course of the sewer to within a few feet of the surface. The precipitous face of the rock towards the Medlock may possibly have formed an old line of river valley before the deposition of the clay, out of which the present river bed has been cut.

The red rock extends to a point near Ackers Street, where it sinks below the level of the excavations; they were not sufficiently extensive to enable the dip to be obtained. The sandstone is covered with a thin bed of red sand, evidently formed by the disintegration of the rock; it occurs in several places at the bottom of the excavations, and evidently denotes that the New Red Sandstone is immediately below.

Overlying the clay and the rock, from Gray Street to Wilton Street, there is a bed of gravel, near Wilton Street it changes to clay, which extends uninterruptedly to High Street.

Below the clay are some thin beds of gravel and sand, in which, immediately opposite Ackers Street, the exceptionally large boulder was found which is now in the quadrangle of Owens College. The clay contains erratics, many of large size, in considerable number, similar to those generally found in the brick-clays round Manchester.

DEPTHS.

A.—Sidney Street.

	ft.	in.
Gravel	9	0
Clay	22	6
Red Sand	2	0

B.–Manhole near Grosvenor Street.

	ft.	in.
Gravel	8	0
Clay	18	0
Red Marl	2	0
Red Sand	7	0

C.—Boundary Street.

	ft.	in.
Gravel	11	0
Clay	18	0
Red Marl	7	0

D.—Rosamond Street.

	ft.	in.
Gravel	9	6
New Red Sandstone	28	3

E.—Clifford Street.

	ft.	in.
Gravel	13	0
Sandstone	13	3

F.—Wilton Street.

	ft.	in.
Loam	9	0
Red Sand	2	0
Sandstone	24	6

G.—Brunswick Street.

	ft.	in.
Clay	16	6
Sandstone	17	6

H.—Dover Street.

	ft.	in.
Clay	21	0
Sandstone	11	0

H 1.—Lamp Eye.

	ft.	in.
Clay	22	9
Gravel	2	0
Shale	4	0
Gravel	1	0
Sandstone	2	0

I.—Ackers Street.

	ft.	in.
Clay	28	6
Gravel (with large boulder)	2	0
Red Sand	2	0

J.—Ducie Street.

	ft.	in.
Clay	34	3

K.—Grafton Street.

	ft.	in.
Clay	32	6
Gravel	2	6

L.—Nelson Street.

	ft.	in.
Clay	25	0
Sand (for a length of 66 ft.)	7	6
Gravel	1	6
Clay	0	6
Gravel	1	6

M.—Thorncliffe Street.

	ft.	in.
Clay	32	0
Gravel	2	6

N.—Stanley Grove.

	ft.	in.
Clay	31	6

O.—High Street.

	ft.	in.
Clay	30	6

Mr. Stirrup said the Corporation of Manchester were at present engaged in prosecuting some extensive sewerage works along some of the main thoroughfares of the city, by which some interesting sections of the underlying rocks were disclosed, and it was desirable that particulars of them should be preserved in the Transactions of the Society. He trusted that they would have from time to time during the progress of the works similar contributions to the one now presented. They had, of course, a pretty fair idea of the superficial strata underlying Manchester from borings for water, &c., but these excavations afford a much better and more accurate account of them.

The President: It is desirable to keep a record of the beds that are met with in cuttings of this kind, because here there are no external outcrops to be seen, and it fixes the positions where the various rocks are to be met with. He supposed it was the upper new red sandstone?

Mr. Sington: Yes.

This concluded the business of the meeting.

Mr. STIRRUP said the Corporation of Manchester were at present engaged in prosecuting some extensive sewerage works along some of the main thoroughfares of the city, by which some interesting sections of the underlying rocks were disclosed, and it was desirable that particulars of them should be preserved in the Transactions of the Society. He trusted that they would have from time to time during the progress of the works similar contributions to the one now presented. They had, of course, a pretty fair idea of the superficial strata underlying Manchester from borings for water, &c., but these excavations afford a much better and more accurate account of them.

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Mr. SINGTON: Yes.

This concluded the business of the meeting.

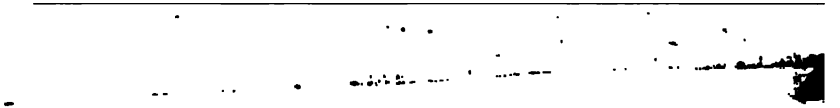
Erratum in Mr. W. S. Gresley's paper "On the occurrence of Boulders and Pebbles in the Coal-Measures."

Since the publication of this paper the writer of it has discovered that the so-called "pebble of lead ore" stated, on page 491, Part XVIII of this Vol. of the Transactions, to have been found in a Shropshire coal-mine, is nothing of the kind. Mr. Gresley begs to apologise for having made this announcement, but as Mr. Spencer, the finder of the geological specimen in question, assured him that the thing was unquestionably a rolled fragment of lead ore, he took him at his word. The object having since then come into his hands for examination he at once saw that it was not an erratic pebble at all but a fossil plant remain. The specimen, however, is an interesting one. It is oblong in form, being about 3 inches long, with a smoothish outside, and seems to be chiefly composed of very hard and compact iron pyrites with some lead ore here and there. It represents, according to Mr. W. Carruthers, F.R.S., Keeper of Botany at the British Museum, Natural History Department, a portion of the interior of some branch or stem of a coal-measure plant, though the fossil is not complete enough to enable him to say exactly what it is It is, however, a beautiful illustration of the way in which Sulphurets of Iron and of Lead (Galena) can assume the form of wood tissue of the most delicate structure, every cell of the vascular tissue being transformed into mineral matter capable of taking a high polish, and yet to the naked eye when freshly broken across, nothing but the

ordinary fracture was apparent. This only shows how exceedingly cautious our observations ought to be, and that to take statements (even made by those upon whom we think we can safely rely) for granted, will sometimes lead us astray. Of course the short paragraph on page 498, relating to this supposed lead ore pebble, must be struck out.

5th June, 1888.

END OF VOLUME XIX.



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